SQUINT
AND
OCULAR PARALYSIS

LUCAS HUGHES

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WITH

A SHORT ACCOUNT OF THE DISTURBANCES
OF MUSCLE BALANCE

BY

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ILLUSTRATED BY THE AUTHOR

LONDON
H. K. LEWIS, 136, GOWER STREET, W.C.
1907

PREFACE

THE study of the ocular muscles and squint has been to me one of great interest for some years, and I have had excellent opportunities of observing cases both in this country and abroad, in hospitals and in private practice. It is quite impossible to add a great deal to the excellent work that has already been done, but I have endeavoured in these pages to bring into line and compare some of the best practical teaching of the English and foreign schools. The object has been to clearly state and emphasize important points; when once these are grasped by the student, much of the dreaded difficulty of the subject disappears.

My warmest thanks are due to my friend and former teacher, Dr. William Murrell (whose clinical clerk I was years ago at the Westminster Hospital), for kindly undertaking to look over the manuscript.

14, FALKNER STREET,
LIVERPOOL,
October 1, 1907.

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PART I

SQUINT

CHAPTER I

INTRODUCTORY REMARKS.—HISTORY OF THE SUBJECT

THERE has always been in medicine a sort of warfare between science and empiricism, and nowhere has this been more the case than in the realm of the pathology and treatment of squint. Owing to ignorance of the true nature of squint, empiricism has had such an advantage that it is only of recent years the subject has been placed on the firm basis of science, and even now the immediate brilliant results of operations upon the recti muscles have seemed at first sight to confirm past erroneous ideas, and to militate against the true and scientific explanation of the facts.

The pathway of science has always been tedious and often extremely difficult to find. The human mind desires a short-cut, a royal road to immediate success. Empiricism offers that road by substituting blind action based upon the jumping at wrong conclusions. Professor Edgar Browne (*loc. cit.*) writes: "Empiricism frequently obtains an apparent victory over science because it offers the bribe of a cure rather than the labour of investigation." Our patients are waiting, and whether we have been taught the right thing or the wrong, whether our reasons for action are scientific or not, there is always desire on the part of the prompt

and practical surgeon to do something; and, indeed, circumstances have nearly always been such that he has not been able to wait for slow but sure-paced science to overtake him. As regards squint in children, the fundamental mistake has been to look upon it as a deformity of the ocular muscles, a mechanical displacement of an eyeball, simply due to anatomical conditions: the supposed shortening of an internal rectus muscle, for example, that has produced a turning inwards of the eye, produced, in other words, convergent squint. Tenotomies for the cure of this supposed muscle deformity have been performed galore, and in many cases with immediate brilliant results, but the ultimate results of quite a number of these operations have proved unsatisfactory. The operation, for many years, was the admiration of the profession, and surgeons enthusiastically "benefited" almost every child they encountered that was seen to have a "turn in its eye." Boys are said to have been brought in from the street to the hospital by ardent operators, and tenotomy (chiefly that of the internal rectus muscle) was all the rage. That the victory of empiricism over science has frequently proved ephemeral, in regard to this operation, may be illustrated by a case in point: "A man, forty-four years of age, amblyopic in the right eye, shows a slight external squint. He has crossed diplopia, which sometimes bothers him, especially when his accommodation is relaxed. The history is that, when six years of age, he was operated on for convergent squint of the right eye. At the age of twenty he consulted an eminent oculist, who prescribed glasses for his manifest hypermetropia. The amblyopic eye had +6 D of hypermetropia, with about 1 D of hypermetropic astigmatism, and there were 4 D of hypermetropia of the left eye. He never wore glasses before the age of twenty. The oculist urged him again to have the internal rectus operated on, since even then he had some amount of convergent squint. However, he refused, and decided to wait and see what his glasses would do for him. The eyes became straight soon after commencing his glasses, which were subsequently altered by another surgeon to a stronger pair, this time the astigmatism and unequal refraction of the

two eyes being prescribed for. With a slight modification, when he came to reside some years ago in Liverpool, these glasses have been worn ever since. With the proper correction, the vision of the right eye has improved, but there has developed a slight divergence, and he shows a shrunken caruncle. Obviously the divergence and the shrunken caruncle are both due to the operation of his chlidhood. What would have happened had the tenotomy been repeated, as was advised, when he was twenty years of age? Undoubtedly, there would have been an extreme divergent squint, needing more operations. Advancement of the opposing muscle has largely superseded tenotomy of late years, except in the slighter cases; but "this is merely shifting the burden from one shoulder to the other, as, whether the leverage of one eye is lessened or the leverage of the other increased, the result is the same. . . . We must not allow our minds to be biased by the facility of an operation or the brilliancy of its immediate results from endeavouring to ascertain what are the reasons why the muscles behave in a seemingly abnormal manner. So long as we regard squint as a muscular deformity, and attempt to remedy it by forcible readjustment of the tendinous attachments, so long are we dealing with effects and not causes, and we are, in spite of all improvements in the measurements, ocular movements, and in the details of surgical procedure, still living in the era of Dieffenbach, and followers of his teaching."

The History of Strabismus.—This is very interesting. Stromeyer and Dieffenbach were practically the pioneers of the modern operative treatment. To them is due the devising of an operation something like our modern tenotomy, but as far back as the seventeenth century a surgeon named Taylor suggested operation. His attempts were similar to those of Dieffenbach in that they consisted in dividing the fleshy part of the muscle, and not the tendon; they were quite unsuccessful, and were therefore abandoned. Stromeyer, in the early part of the nineteenth century, began to perform myotomy (not tenotomy) upon the cadaver, but it was not until the year 1839 that Dieffenbach began to perform his myotomy operation upon living

patients, and introduced it into practical surgery. When he announced in 1840 to the French Academy of Science that he had cured at Berlin many cases of squint, eminent French surgeons of the time—namely, Roux, Velpeau, and Sédillot—commenced to practise the operation, but with utter want of success. It needed Philips, Dieffenbach's pupil, to come to Paris to show them how his master operated. "The aponeurosis (Tenon's capsule) was largely separated, and the sclerotic denuded for about a third," Bérard (*loc. cit.*).

The ultimate results of this practice were, however, found to be disastrous, causing secondary strabismus, with retraction of the caruncle and exophthalmos. A great advance was made when Bonnet of Lyons first introduced cutting the tendon instead of dividing the muscle, showing, after an excellent study of Tenon's capsule and the muscular insertions, that to sever the fleshy fibres was altogether unnecessary. Von Graefe has generally been given the credit of suggesting tenotomy, but the French all assert that the honour of its introduction really belongs to Bonnet of Lyons.

Another Frenchman, Jules Guérin, was the one who first conceived the idea of performing an advancement operation. He thought of it as a remedy for a secondary divergent squint, the result of an unfortunate tenotomy for convergent strabismus, this occurring so frequently in his day. Subsequently George Critchett (*loc. cit.*), Liebreich, de Wecker, and others, caused the operation to become generally known. Landolt showed that excellent results could be obtained by an advancement, in a bad case, performed upon the two eyes.

Squint in children is not, as is so commonly thought, an affection simply of one eye. The deviation is apparent of one eye, but it is really an affection of both. One eye is the apparently good one—*i.e.*, the straight or fixing one, according to circumstances to be shown later. Suffice to say now that if the squinting eye is made to fix, which can always be done in recent cases, the fellow eye will be seen to squint in the same manner, and, indeed, in the same degree (concomitant or comitant squint).* This is called "the secondary

* Term used indifferently by authors.

deviation." Some cases are known as "alternating squint," each eye taking its turn to do the squinting, while its fellow is performing the duty of fixation. The vision of both eyes, in these cases, as a rule, is good, and there is some degree of the faculty of blending the two retinal images of an object, so that the brain can appreciate them as one the fusion (faculty). To continue the history of strabismus: About the same time that Donders was doing splendid work, in showing the relationship that existed between accommodation and convergence, and the rôle frequently played by errors of refraction as a chief contributing factor in the etiology of squint (hypermetropia in convergent and myopia in the divergent variety), Mr. George Critchett, of Moorfields, was introducing important improvements in the operative technique. This attracted a great deal of attention, but it unfortunately had the effect of hindering Donders' theory doing the immediate good it otherwise would have done. Thus, in the face of science, because of operative brilliancy, the untrue antiquated muscle theory continued to live—indeed, seemed to take on new life—although Donders firmly laid the foundations of our modern conceptions of squint and gave the muscle deformity idea its future death-blow.

With Donders began a new era, but it is a mistake to suppose that no one before him ever had questioned the false theory of squint that was universally believed during the first half of the nineteenth century. As far back as 1743 Buffon contended that it was a functional and not a mechanical trouble; he was unable, however, to bring forward clear scientific proof, as Donders has done. M. de la Hire and several others, who lived long before Dieffenbach, held ideas about squint which were an approximation, as far as they went, to the sound reasoning and scientific teaching of Donders. De la Hire believed that the squinting eye deviated because the most sensitive part of its retina happened to be away from the path of the optic axis, and in order to adjust objects fixed by the other eye, the squinting eye took up a wrong position. He made an effect, and a late manifestation of squint, the cause, since that which sometimes happens in a squinting eye, and which

has been described as the eye trying to rig up a sort of "jury macula" (false macula), only occurs when fixation of the affected eye is entirely lost. This, at least, shows that in days long ago there were minds, scientifically inclined, who were not satisfied with mechanical ideas, and were groping for the light which has now come.

It is to Dr. Emil Javal we owe much of our knowledge concerning squint. Besides continuing, as Donders has done, to throw light upon its pathology, he suggested something more than the correction of abnormal refraction with glasses in its non-operative treatment. In his "Manuel du Strabisme," published in Paris in 1896, he brought forward much evidence to prove the value of stereoscopic exercises, bar-reading, and other orthoptic measures for the eyes. Parinaud, three years later, wrote an excellent treatise on the subject. Much good work has been done by the French, while English and German minds have been engrossed in the improvements of operative technique. Recently, however, Professor Edgar Browne and Dr. E. Stevenson, both of Liverpool University, published a small book upon the subject. It is a pity this essay is not longer. Also a much larger work by Mr. Claud Worth has been published. He shows that refractive error, important as it is, is not the only cause of squint, but of equal, if not greater, importance is the development of the faculty of fusion in bringing to perfection binocular single vision, an almost certain safeguard against convergent squint. He invented a special kind of instrument, which he calls an amblyoscope. It is a valuable one for orthoptic treatment, accomplishing in favourable cases its purpose—that of training the fusion faculty in young children and preventing amblyopia. The instrument is said to be something more than one variety of stereoscope, as it is worked with powerful transmitted light to prevent one eye suppressing its retinal image. Priestley Smith also called attention to the orthoptic treatment, and invented a convenient form of stereoscope, called a heteroscope.

Operation cannot restore binocular vision; it improves, when successful, matters for the artist and admirer of beauty,

but it cannot cure amblyopia—that is, the partial blindness that has resulted by suppression of images on the retina of the squinting eye. This is the worst thing about squint, worse than the deviation, which is bad enough. Non-operative treatment is directed chiefly towards the development and preservation of vision in both eyes, in the hope that, by attention to a purely psychical faculty, that of the blending of images, the exercise of that faculty will bring the squint straight of itself. The eyes cease to deviate ; post-mortem they take up, like all other dead eyes, the anatomical position of rest, and careful dissections of the ocular muscles, after concomitant strabismus, do not show any anatomical changes.

Orthoptic exercises preserve vision, prevent amblyopia, and develop in the young the fusion faculty ; they gradually, in a physiological manner, do all that operations are expected, cosmetically, to do without the slightest danger of any ill effects. Operation is called for in neglected cases and in bad cases where other means have failed. It is of immense value in its proper sphere as a secondary measure, but there should always be an intelligent appreciation of the true pathology of strabismus, and an attempt in most cases to bring about amelioration by non-operative measures.

Parinaud (*loc. cit.*) strongly condemned unnecessary operation in young children. He writes : " I am far from denying that great improvements have been realized in the surgical treatment of strabismus, but it is a mistake to wish to reduce its treatment to a mere question of operative technique. Precision should be sought on the one hand in acquiring a deep knowledge of the pathology of strabismus, and, on the other hand, in the analysis of the mode of action of our operations. It is manifest that in directing our operations against a muscular affection that has no existence, we have done, up to now, what we have never meant to do. How can precision ever be found in a path thus obviously a wrong one ?"

After operation, as well as before, stereoscopic exercises, exercises with the amblyoscope, with the diploscope, and

other orthoptic measures are of great value. The patient must continue wearing the glasses which correct his refraction. The treatment means the expenditure of time and trouble, but it is the ideal one, founded upon true pathology. The difficulties of carrying it out are not insurmountable: the busy oculist could arrange with a junior confrère who has more time to spare. I do not wish to decry operations—they are excellent in their proper sphere—but they should be performed some little time after the second dentition, when the critical nervous age, peculiar to chorea and other neuroses, has been passed, and when milder measures have been tried and failed.

Those who have had the opportunity of seeing cases in after-years that had persevered in non-operative methods of treatment can testify to their value in numerous cases. The result may even surpass the best operative cases, both optically and in appearance.

CHAPTER II

BINOCULAR SINGLE VISION.—FIXATION AND FUSION TENDENCIES.—RELATIONSHIP OF CONVERGENCE AND ACCOMMODATION

MAN normally possesses binocular single vision. This is dependent upon the partial decussation of the optic nerve fibres at the chiasma. Both eyes lie in the frontal plane, therefore almost all the objects, seen with both, perceived simultaneously, have their two retinal images blended together as one. The visual fields of the two eyes are indeed so blended (up to 60 degrees above and on each side, and 70 degrees below) that it is only on each side in a crescentic area, as shown in the diagram (Fig. 1) that there is any single vision peculiar to each of the eyes (monocular vision). This can be seen by taking a chart-paper, such as is used with a perimeter, cutting it vertically in half, making one field overlap the other, so that the circles are accurately behind each other, the horizontal meridians of the two eyes in the chart being on the same level, and the two blind spots being on each side of the centre circle. Two sheets of white paper, cut out the shape of two visual fields and partially placed, the one behind the other, will roughly demonstrate the same thing.

The study of binocular vision is exceedingly interesting, especially when we compare it with what exists in the lower animals. There we find absolutely monocular vision with each eye, each visual organ acting independently. The simplest forms of this occur in fishes, where we find the optic nerves merely cross each other, or one passes through

a slit in its fellow. In the amphibia and in birds there are like conditions, only slightly more complicated, since in them each optic nerve consists in a number of flat bundles, which interlace, as they cross, with those of the opposite side, like the intertwined fingers of two hands clasped together. As we ascend the scale and arrive at those animals

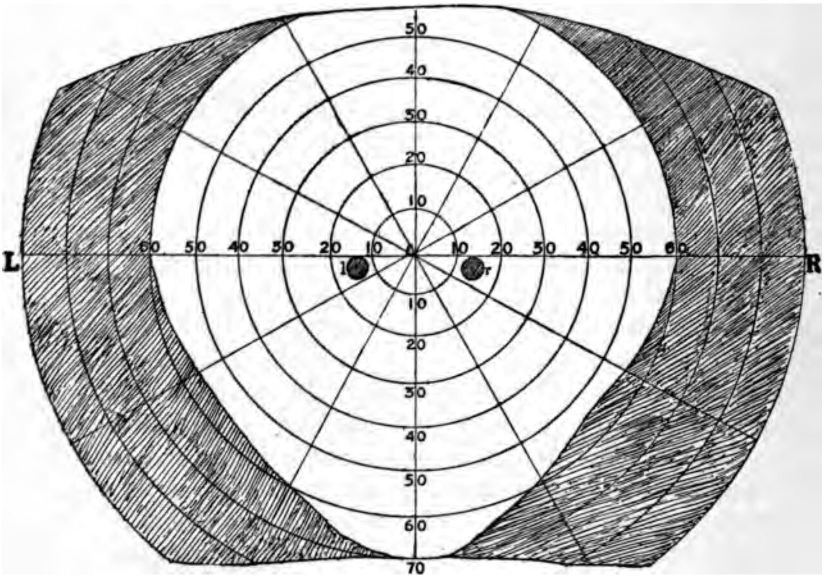


FIG. I.—BINOCULAR FIELD OF VISION.

The median portions of the two fields are common to both, forming one binocular field to the extent shown by the surface left white, which is almost a circle of 60 degrees radius, except below, where it reaches to 70 degrees; in the centre is *f*, the point of fixation, on each side of which are the two blind spots *r* and *l*, which correspond to the optic papillæ of the two retinæ; adjoining either side of this binocular field are the temporal divisions of each visual field (the shaded areas); objects here are seen with one eye respectively.

nearest man, the higher vertebrata, decussation becomes partial, and we begin to find the visual fields blending together, thus giving to the brain blended or binocular single vision. There is a certain amount of this blended or binocular vision belonging, therefore, to the higher animals, and in an uneducated form to the human infant,

but binocular single vision in its perfect form belongs to man. The more the decussation becomes partial, the more there is of this blended vision, so that fibres crossing at the chiasma are relatively less in man than in other animals because binocular vision is far greater. In the dog there is more blended vision than in the horse, but less than in man. Independent vision of each eye—*i.e.*, monocular vision—plays a far larger part with the horse, whose eyes have been more laterally placed than those of man or even than those of the dog. This animal, seeing objects to his right entirely with his right eye, and objects to his left entirely with his left eye, the part of his harness called blinkers has to be put over the eyes when he is driven in a carriage or cab, otherwise the animal would be confused and frightened while passing rapidly the numerous objects seen in his two visual fields. Separating his two fields there exists a blind vertical band, in the median line, corresponding to the glabella, and on each side of this, divided by it, there must exist some blending of visual images, some vision common to both retinæ, proved by the existence of a few non-decussating fibres in the optic tract of this animal. Supposing this were not the case, it would be impossible to explain the surefootedness, the way in which dangerous objects close by are avoided in battle and in the hunting-field, the accurately measured distances in jumping, etc. Binocular vision, however, is not of the same importance for the higher vertebrata as it is for man; there is not the demand for convergence, and they are never observed to squint, unless it be from paralysis; the palpebral fissure is much rounder, the cornea is relatively larger, and fills it almost entirely, and they do not possess the same range of associated ocular movements as in man.

The most accurate description of intelligent binocular vision, as it occurs in man, is the describing it as "an educated cerebral or psychical blending of the two sets of visual impressions that are focussed on more or less functionally corresponding portions of each retina." It is the result of frequent stimuli to which the two eyes are constantly subjected, beginning at the moment of birth until the

child learns at last to observe intelligently with its visual organs *pari passu* with mental development, and it is thus as much a matter of educative practice as is walking or speech. A child that squints is like an individual that speaks badly or walks awkwardly: he has never properly learnt to use his two eyes—something has happened to prevent it. The dog, like the young infant, sees images with its two eyes simultaneously blended, but even this animal can never reach the perfect binocular intelligence associated with human binocular vision. It is our brains that really see, not our visual organs; the child's brain becomes conscious of only one picture, and learns to intelligently appreciate its reality.

Claud Worth has shown the existence of a marvellous elasticity of this psychical fusion process, which is developed in early life. This he calls the faculty of fusion, and by it images, seen binocularly, are maintained as such during accommodative alterations of focus for near and for more distant objects. The images are said to fall upon anatomically corresponding points of each retina when the accommodation is completely relaxed, as in looking at objects that are in the extreme distance; but this is not the case in near vision, nor even in vision at medium distances. There exists, therefore, this psychical elasticity which maintains fusion, and it is a faculty that is purely cerebral, the fusion faculty. Anything that places this faculty temporarily in abeyance brings into evidence what is termed "physiological diplopia."

It is upon this fact Dr. Rémy of Paris has recently based the action of his ingenious instrument, the "diploscope," to the description of which I shall devote part of the next chapter. Physiological diplopia may be experienced without much difficulty by looking at two candles. Place (Fig. 2) the first candle A at about 60 centimetres (2 feet) from the observer, and the second candle B at about 120 centimetres (4 feet). When the observer fixes his eyes upon B, the candle A will look double, and with a red glass before one of his eyes the two images of A will be seen to be crossed; that is to say, the left eye sees the right image and the right

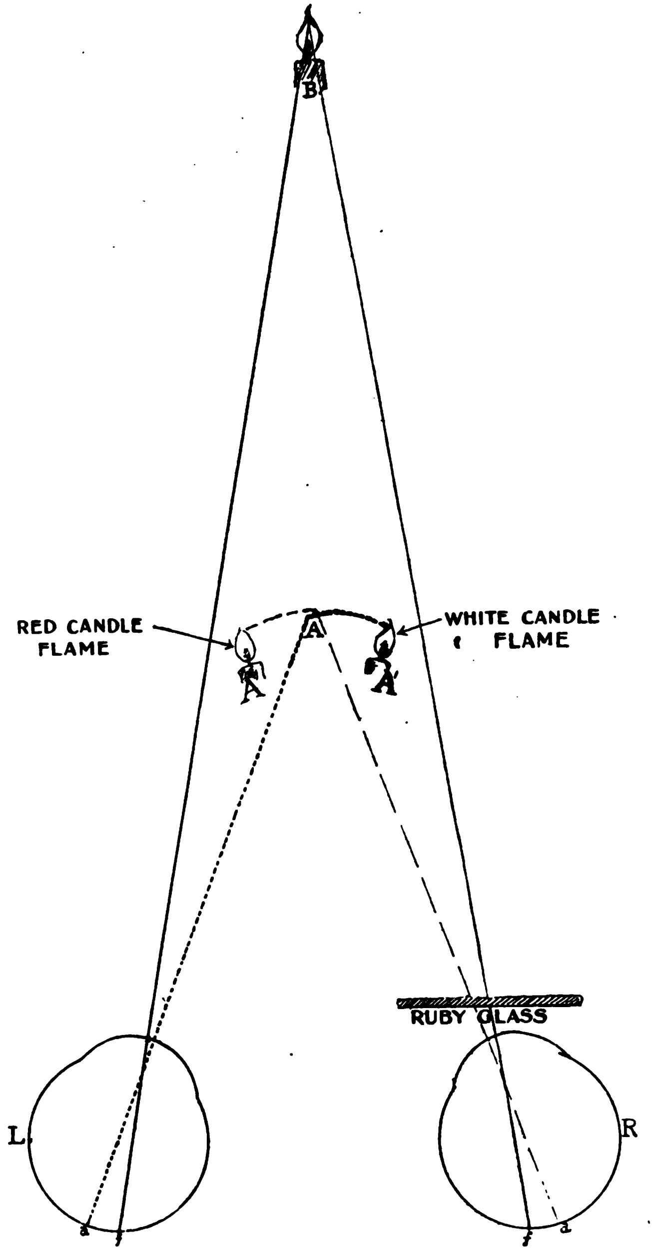


FIG. 2.—DIAGRAM TO ILLUSTRATE PHYSIOLOGICAL DIPLOPIA WHEN THF OBSERVER IS LOOKING AT THE FARTHER CANDLE B.

eye sees the left (heteronymous diplopia). The opposite to this takes place if the observer fixes A (Fig. 3), then the second candle B is seen double, and the images, instead of being crossed, are homonymous—that is to say, seen directly. Binocular single vision is divided into three grades: the lowest grade is (1) simultaneous macular perception; the second grade (2) has true fusion with a certain amount of amplitude; the third grade (3) has the sense of perspective. One of these grades must occur in all those cases of squint which possess any binocular vision at all. In the lowest grade there are two separate pictures seen in the stereoscope, which only form one picture when the two are in certain relative positions that correspond with the independent directions of the visual axes according to the strabismus that exists. These cases make no effort to maintain fusion of images, since they have no desire for true binocular vision. Simultaneous blending of images exists, but only under those conditions which are produced artificially by means of a stereoscope. The educative stimulus which develops the fusion faculty is the one thing needed. In the second grade or class of cases we find there is fusion of images, and not only so, but it is to some extent maintained. In the third—*i.e.*, the highest grade—the eyes are able to see from slightly different points of view This gives the idea of perspective—*i.e.*, the psychical impression of solidity; for example, in looking at a pillar the right eye will see more of the right side of this solid object and the left eye more of the left side. It is these slight points of difference in the two eyes that are suppressed or undeveloped in the second grade of binocular vision.

There are several interesting points brought out clearly by observations made upon the eyes of young infants, specially relating to the normal development of this fusion sense, upon which, as we have already seen, intelligent binocular vision depends. Fixation is purely reflex in the first few weeks of life, and it is not maintained except for, at most, a very brief moment. It takes several months of life before the movements of the eyes come entirely under the control of the higher cerebral centres; thus we have

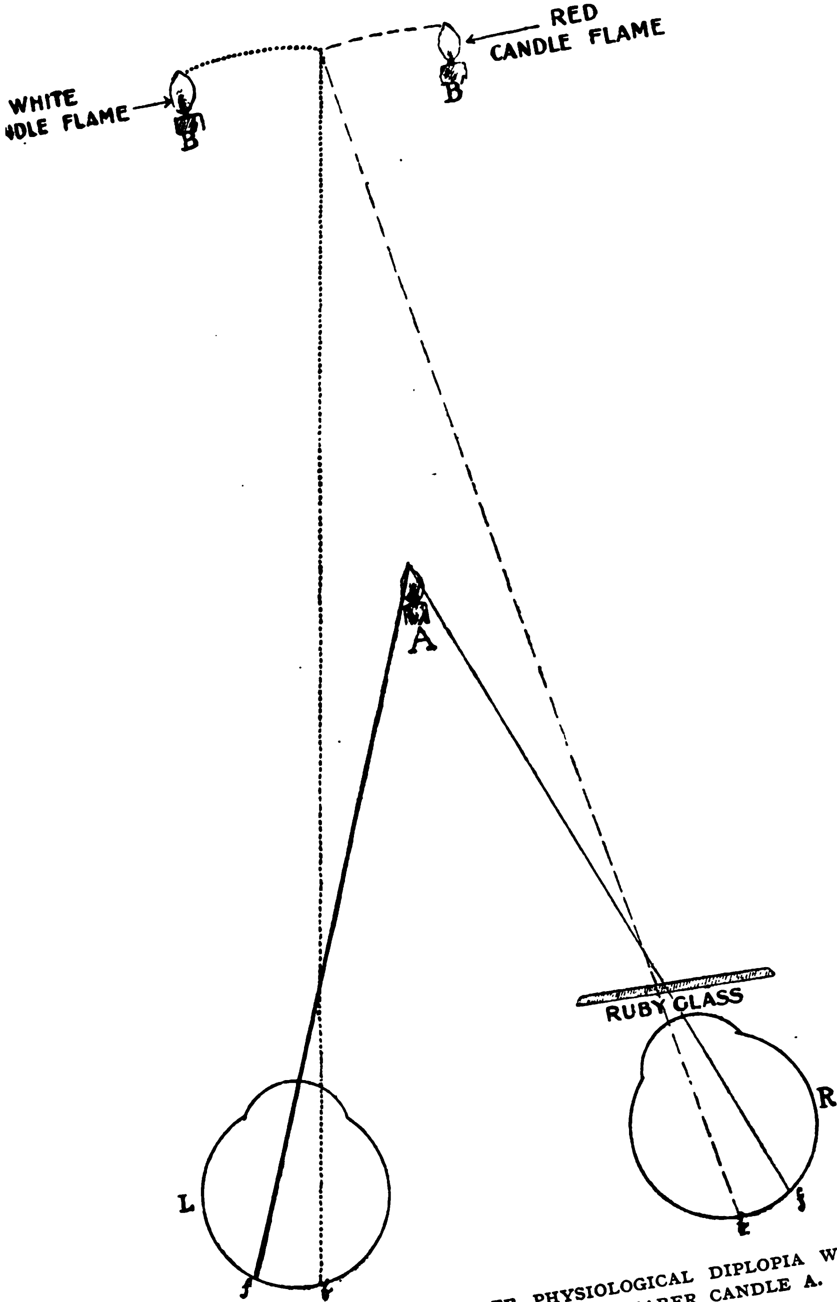


FIG. 3.—DIAGRAM TO ILLUSTRATE PHYSIOLOGICAL DIPLOPIA WHEN THE OBSERVER IS LOOKING AT THE NEARER CANDLE A.

gastric disturbances, even of the slightest degree, frequently causing temporary deviation of one or the other eye. This absence of co-ordination, however, is observed to be confined mostly to the movements that are in the horizontal plane. Bearing upon this subject, Dr. Emil Javal (*loc. cit.*) says: "Like all the other organs of special sense, the eyes undergo, from the moment of our birth, an education, thanks to which they acquire an ability, which becomes more and more perfect, to keep us informed on the nature of external objects, and one of the effects of this education ought necessarily to be that the diplopia, which, undoubtedly, the new-born child at first experiences, is made to disappear. The very young child exerts itself to turn its two eyes simultaneously towards the same object and to combine into one the images that are formed on its two retinæ. This is so true that no one can say with certainty whether a new-born child squints or does not squint. It passes through a period of ocular indecision during days or even weeks. We hardly ever encounter cases of squint that are really congenital, and when a patient is presented to us as having always squinted, we are nearly always able to find that he has been attacked, during the first few months of life, with an ophthalmia which has caused complete suppression of the visual function during that period of time when the muscles moving the eye have been taking their definite shape."

In contrast to the horizontal movements, conjugate movements of the eyes, in young infants, upwards and downwards are much more decided; these seem to be well developed even from the very earliest infancy. "By slipping a prism of 12 degrees, apex towards nose, in front of an infant's eye, say of six months of age, the child's attention having been directed to some bright object, it is possible to determine whether there is not some amount of binocular vision. If this has, to some extent, developed, the eye behind the prism will be seen to make a slight inward rotation. If there be no movement the vision of this eye is probably suppressed." At least is it obviously not being used. "Here we have a resemblance to certain cases of

occasional squint, where there is binocular vision when the eyes are straight, but suppression of the vision of the deviating eye when a squint is manifest. After the first year a child almost always turns the eye in, so as to blend the images, when a prism is placed in this way before the eye; the eyes will then make a considerable effort in the interests of binocular vision. . . . If the obstacle prove insuperable, the child will suffer from diplopia, being no longer able to suppress the vision of one eye" (Worth). At the age of six the faculty of fusion has reached its full development.

The development of the fusion faculty as the one thing needful to bring about intelligent and perfect binocular single vision is borne out by Parinaud (*loc. cit.*). He says: "Binocular vision has always been considered the same as vision with the two eyes. But there are two kinds of vision with the two eyes: one should be called 'simultaneous vision,' the other is, properly speaking, binocular vision. For each kind of vision there corresponds a special organic arrangement. The mechanism of simultaneous vision is more fundamental, more solidly established in an hereditary basis. Binocular vision, on the other hand, appears to us more like a sort of finishing touch, a greater perfection of function; its mechanism is of more recent date in the *phylogenetic** order, and it is more fragile, more susceptible to errors of development, when obstacles to its proper performance exist in infancy. For the same reason, it is also the more capable of being improved by exercises. This explains to us why the alteration of the visual mechanism which characterizes strabismus is limited to the mechanism of binocular vision, with due regard to that of simultaneous vision; this explains why squint is an affection of young childhood, or, at least, always having its origin in alterations which have existed from earliest infancy; finally, this explains the utility of exercises which entice into action and regulate the binocular vision, when they are practised before functional alterations have become too pronounced."

The inference, therefore, is quite clear. Convergent

* The development of racial or typical forms.

squint (the common form) happens because of the absence or defect of binocular single vision, and this chiefly because of some interference with the development of the fusion faculty. Because the fusion faculty is more needed the nearer the objects are that are looked at, distinct vision being a necessity, it is convergent squint that is especially the variety caused by the absence, or, at least, the imperfect development of this faculty. Because of its absence or poor development, the visual axes converge asymmetrically, so as to become, relatively to each other, set in a wrong position. Refractive errors—especially hypermetropia, with its unceasing struggle to maintain a degree of accommodation, together with an associated amount of convergence—help largely in bringing this about. One thing reacts upon another. Because of erroneous refraction the fusion faculty is hindered in its development, and because of the faculty's imperfect development the error becomes maintained and intensified. Things, so to speak, are thrown out of gear, so that when the child uses his accommodation with its convergence disassociated in an abnormal manner, he more and more falls into the habit of monocular fixation—in other words, he squints, for this means the occurrence of over-convergence of the other eye ; the squinting eye is in such a wrong relative position that it is rendered useless for vision. Thus a sort of disregard of that eye becomes established in the child's brain just at a critical time in his growth and development. It is vain to argue that because childhood happens to be a time of development, the idea of an eye's vision being suppressed at that age is unphysiological. There may be congenital or other reasons why an eye is not used, but the fact is proved that, in a large majority of cases, the eye has simply fallen the victim to a bad habit of neglect, the result of educative defect. Diplopia does not arise from the deviation, because it is avoided from the first by the brain ignoring the images on the retina of the squinting eye. There has never been any proper education for the eyes to act together and to blend their retinal images binocularly in near vision ; consequently, although there is, and always has been, that which Parinaud designates

"simultaneous vision," the vision of the one eye only is actively appreciated by the brain, while the vision of the other is latent. It is helpful to compare the two eyes to a pair of horses, the driver of which should have his reins well in hand. The reins are like the recti muscles, and the brain we may compare to the driver There is nothing whatever the matter with the reins, and the driver is intelligent, but perhaps he is nervous, unskilful, or has never properly learnt how to perform his work. How useless to operate on the reins when the reason is the lack of education of the driver! The horses do not run together harmoniously because the driver is untrained.

This neglect of the brain to notice the vision of the squinting eye goes on after a time to actual amblyopia—that is, partial blindness. The technical terms are amblyopia ex anopsia and amblyopia from disuse. Suppression of an eye's vision may be temporarily and without difficulty exercised by the will in after-life, as when a sportsman shoots with both his eyes open he only uses the one that he aims with. The medical student when he begins to practise the use of the ophthalmoscope is another example of this voluntary suppression of the eye that is not being used; he is taught, while making an ophthalmoscopic examination, to keep both his eyes open. The same thing is usually done in looking through an ordinary microscope. The practice of this voluntary suppression, or disregard, of the vision of one eye never produces squint, simply because the fusion faculty and perfect binocular single vision has long before become established. A man can hop at will on one leg, but the use of the two together has, early in life, become his habitual practice. When once the fusion faculty is developed, it is as impossible to unlearn the habit of binocular vision, that depends upon it, as it is to forget how to skate or swim when once these have been thoroughly learnt, or even to forget how to walk when this has once been acquired.

Fixation and Fusion Tendencies.—Because the habit of fixation with both eyes and the fusion of retinal images are well developed in normal vision, and—by means

of the fusion faculty—because unimportant differences of detail belonging to each image are unobserved, the experiment with the two candles may, at first, be a little difficult, especially if a red glass is not placed before one eye of the observer. The very looking for any physiological diplopia will cause it to disappear. For the same reason, a beginner in ophthalmoscopy finds extreme difficulty in relaxing his accommodation, since his desire to see the fundus clearly instinctively calls into action his accommodation, and needs a specially trained will-power to overcome it.

This concentration of the mind upon the object looked at causes the act of fixation. Fixation is an extremely important characteristic of the higher animals, one upon which we cannot lay too much stress. It is really a psychical act, and is therefore a great deal more than the mere bringing of an object looked at clearly upon the most sensitive part of the two retinæ. Indeed, the point of clearest vision of an eye and its point of fixation do not invariably exactly correspond. There are squinters who are able to straighten a deviating eye, if the other is covered, and fix an object with it, but in doing so the object comes to be seen much less distinctly than before, when the eye was unfixed. This is due to the fact that the eye has "rigged up a jury macula," and has come to neglect its true macular vision. Those who become suddenly affected with a central scotoma manage, in the same way, to find some other point near the macula which serves as a new macula, and, in their case, this is the fixation point of that eye.

Relationship of Convergence with Accommodation.—Under normal conditions any variation of the convergence is always accompanied by an exactly corresponding proportionate variation of the accommodation. In other words, just in proportion as the eyes converge, so as to look nearer and nearer, the accommodation becomes more and more called into play in a perfectly regular manner. The internal recti muscles and the ciliary muscles thus act in a perfect unison. Although accommodation is quite involuntary, convergence is a voluntary act. Both these acts depend upon the desire for fixing the eyes upon a near

object. Although they work hand-in-hand, under normal conditions, having this unvarying relationship, they are completely independent of each other in their amplitudes. The amplitude of convergence means the full amount that can be put into force; it necessarily varies in different individuals, but remains about the same as age advances. On the other hand, the amplitude of accommodation keeps growing less as the age advances. The range, but not the amplitude, of accommodation is modified by refractive errors, the amplitude being according to the patient's age, whatever may be the refraction. In hypermetropia some of the amplitude—*i.e.*, power to accommodate—is called upon to compensate for the lessened range, in order to maintain clear vision, even, for example, when looking in the distance. Because of this tax upon the accommodation, in convergent squint cases with hypermetropia, the normal relationship between the convergence and the accommodation becomes broken. Thus we see the immense rôle that hypermetropia plays in convergent squint cases, although there exist many cases of hypermetropia without any squint at all. Given an undeveloped or imperfectly developed fusion faculty, we may safely say that a hypermetropic child is certain to squint, as soon as it begins to exercise its power of accommodation. Hypermetropia is almost always the refractive condition of the eyes in early childhood, therefore the frequency of convergent strabismus. Along with the demand upon the accommodative power, there is an excessive demand upon the convergence, with no fusion faculty, or only an imperfect fusion faculty, to keep that convergence in check. The convergence is untrained because the fusion faculty is undeveloped. The internal recti muscles are normally stronger than the external, therefore in this call upon the convergence one of the external muscles has to relax; it fails in maintaining the equipoise. Which external rectus gives way depends upon circumstances, such as a larger degree of ametropia of one eye (anisometropia), the presence of astigmatism in one eye, corneal opacities, etc.

Donders based his theory on the above-mentioned

relationship, but, then, he only took into account hypermetropia for convergent squint, and the opposite refractive error—*i.e.*, myopia—for divergent cases. Partly accepting his theory, we urge its modification in emphasizing the immense importance of the lack of development of the fusion faculty. Indeed, this is the ruling factor in the causation of convergent cases. Unless the fusion faculty be properly developed, be the refraction what it may, there can be no proper binocular vision. Whatever weakens one eye, especially an eye already impaired, assists in bringing about a squint. Because the eyes in hypermetropia are never at rest, hypermetropia plays by far the more frequent part, but it sometimes happens that convergent squint obtains in emmetropia and even in myopia.

No doubt the breakdown of the normal relationship between accommodation and convergence largely helps to bring about the deformity, happening at a time when fusion faculty development should be taking place so as to bring about and maintain, at all distances, intelligent and perfect binocular vision.

CHAPTER III

THE DIPLOSCOPE.—OTHER TESTS FOR BINOCULAR SINGLE VISION

One of the simplest and best instruments I have seen on the Continent for testing binocular vision is the diploscope of Dr. Rémy in Paris. It is used in the " Clinique Panas " at the Hotel Dieu, in the Paris Eye Hospital of Quinze-Vingts, in the clinique of Galowzowski, and elsewhere in Paris. It is an instrument that will be generally used when it becomes known to oculists, as it is based upon scientific principles, and is perfectly satisfactory in its results. Besides being useful for the immediate detection of the presence or absence of binocular vision, it is useful for orthoptic exercises in squint, in heterophoria, etc. (*vide* Appendix), and is of immense service in medico-legal cases, the detection of malingerers, the most cunning of whom cannot succeed, with its use, in avoiding detection, provided letters are used on the cards which they cannot guess at. In countries where there is conscription, and men try to evade military service by pretended blindness of one eye, such a device as this of Rémy's will prove of the utmost value.

The instrument consists of a wide, short, hollow cylinder. This can be easily made of any material, such as tin, cardboard, etc. It is blackened on the inside. The dimensions are in length 28 centimetres, in breadth or diameter 9 centimetres. It is open at the proximal end, and closed by a disc at the distal end, which disc has four round holes, about 2 centimetres in diameter, two of which are 4 centimetres apart, and the other two 1 centimetre apart. By revolving

a little shutter one pair of holes is kept closed while the other pair is open, and by revolving the disc the pair which is open may be set at an angle that is required for the test. In front at the open end of the cylinder there is a black square frame to block off extraneous rays of light, and a black bar at the top of the frame may be lowered vertically across the opening, moved at an angle to one or other side, or lifted up away from the opening altogether. The frame has two shutters on each side of the opening. This cylinder is mounted on a long rod, the axis parallel with the rod, so that the disc containing the holes is situated exactly

FIG. 4.—CHILD LOOKING THROUGH THE DIPLOSCOPE.

midway between the two ends. The proximal end has a chin-rest for the patient, and the distal end has a holder for the test-cards. The length of the rod is 120 centimetres, so that the disc, midway between, is placed at 60 centimetres. The whole thing mounted on a stand with an arrangement for lowering or heightening it will suit the convenience of any patient, except that a small child looking into it would be better standing on a stool a short distance from the ground (Fig. 4). The rod can also be moved up or down at any angle by means of a hinge, and brought parallel with the stand when the instrument is not in use, so that it takes up very little space in the room. There are two sets

of test-cards. One set consists of four letters placed horizontally, and the other set consists of two letters placed vertically, the one above the other, some of the cards being black letters on a white ground, and others white letters on a black ground, by way of variety. Those on the horizontal cards are about the size of No. 12 Snellen, and those on the vertical are about the size of No. 9. Some of the instruments in Paris have a revolving case containing as well smaller types. These are beautifully made instruments in metal, sold by the Paris opticians, costing 80 to 100 francs; but one could be easily extemporized with a long wooden rod and a cardboard cylinder. Two caps, each with a pair of holes, could take the place of the disc, and it could be made for a few shillings. Instead of the type letters small pictures could be designed for young children to look at. The first test is with the four horizontal letters; these are placed in the cardboard holder so that the fork of the holder grips the card exactly between the two middle letters. The holes are those that are the further apart, and they are placed horizontally. Supposing we have four consonants, such as G, M, R, X (Fig. 5, A and B): while the patient looks at them through the instrument, if he has binocular vision he can see all four, because instead of seeing only the two holes—that really exist—he sees four holes, and sees one of the four letters through each hole seen. This is exactly similar to the crossed diplopia obtained by the experiment of the two candles, the two holes taking the place of candle A, and the four letters taking the place of candle B (Fig. 2). To clearly understand this compare the diagrams (Fig. 5) with Fig. 2. The first and third letter is seen with the right eye (Diagram A), the second and fourth letter with the left eye. Each eye sees a letter through the false or second image of a hole. Consonants are always used for malingerers, but alternate consonants and vowels are better, when it is simply a question of quickly finding whether the patient has or has not binocular vision. If he has suppressed the vision of one eye, as in convergent squint, he will not be able to see the letters belonging to that eye, and will see only two holes in the diploscope. For instance, if he has

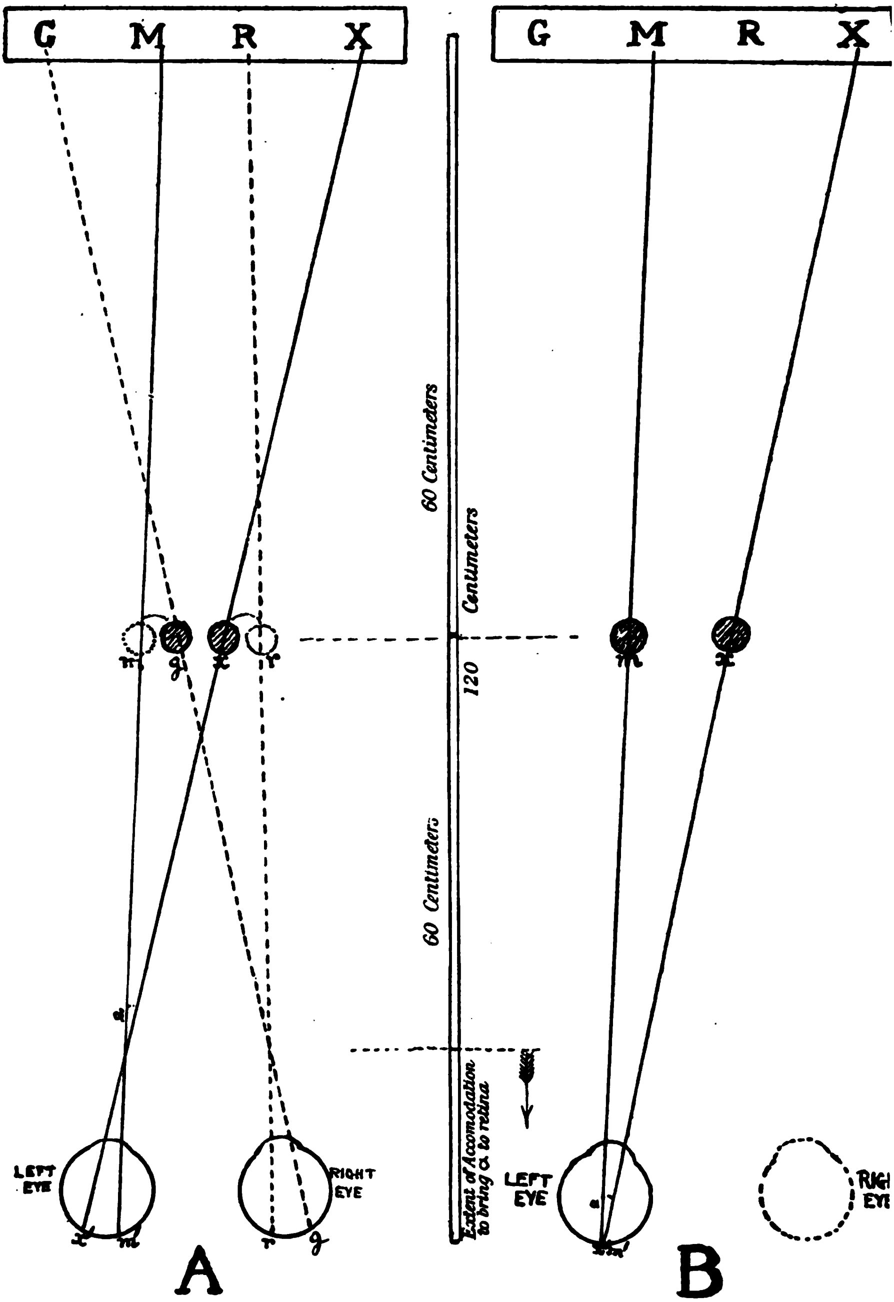


FIG. 5.—DIAGRAMS TO ILLUSTRATE RÉMY'S DIPLOPIA-INDUCING INSTRUMENT.

h eyes are open and looking through the instrument. There is crossed diplopia of the two holes, the outer ima virtual or false, the inner actual or true (*vide* Fig. 2). *B*, The right eye is closed; the left only sees its t There is no diplopia, and the letters are seen because the left eye accommodates, shown by the angle *a* be t up to x^1 m^1 on the retina.
four letters are appreciated by the brain in their proper sequence owing to the psychological fact orientation (*vide* Chapter X.).

suppressed vision or is amblyopic of the right eye, his left eye will see the second and fourth letter; as an example, in the card D, O, G, E, only the two vowels O and E will be seen through two holes of the instrument. In Fig. 5 B the letters M and X would be those that are seen, physiological diplopia being binocular; but the one eye still views the same letters as when both eyes were open, although the two holes are real and the only ones that are seen. The explanation of this is that the left eye accommodates so as to bring the two letters proper to it through the two actual holes. Diagram B represents the right eye closed, or at least not seeing; the letter M is still seen by the left eye, because the angle marked *a*, in front of it, is brought up to the retina at x^1 m^1. This graphically shows the amount of accommodative effort. It is the invariable rule, with the holes furthest apart in the diploscope, that the first and third letters, corresponding to odd numbers, are always those seen with the right eye, and the second and fourth letters, corresponding to even numbers, are seen with the left eye, the card, of course, being placed in its proper position. If the patient saw only, say, the first and fourth letters, he would have bad vision, but he would be using his two eyes (binocular vision); on the other hand, if he saw only the first and third, he would be using only the right eye (monocular vision), and would be unable to see with the left. We see, therefore, what an excellent test for binocular vision we have in this diplopia-inducing instrument (*vide* Appendix). It is claimed that if a patient will persevere, constantly trying to read all four letters through the diploscope, the sight of an amblyopic eye will be restored, and the squint straightened. It is a good instrument for children decidedly amblyopic, with convergent squint, over the age of six or seven years. Under that age Worth's amblyoscope may be the better instrument. The diploscope being worked at a medium distance does not call so much for the exercise of convergence and accommodation, and if it is possible to restore binocular vision, and develop some amount of the faculty of fusion, the diploscope certainly is the best instrument for doing it.

Rémy claims that his instrument has an advantage over any form of stereoscope, in that it brings about natural binocular single vision by its use, and not the artificial or stereoscopic vision. Patients I have seen using the instrument in Paris have been distinctly benefited from its use.

By means of the vertical cards, there are exercises for the treatment of disturbances of muscle balance (*vide* Appendix), and with the two holes close together, placed horizontally, an attempt can be made to fuse the two middle letters into one, as two vowels forming a diphthong, something like that of stereoscopic fusion. Rémy also has a small model for exercises at the reading distance, which has only the disc, the tube being unnecessary. He has published a treatise that fully describes all the details in connexion with the use of his instrument.

There are several other excellent tests for binocular vision, more generally known than that of Rémy. Cuiqnot's simply consists of what is known as bar-reading. A pencil or pen is held vertically, at right angles to the lines of a printed page, between the page and the eyes. A patient with binocular vision is able to read the letters behind the bar, but if only one eye is being used for the reading, part of the print will be completely hidden by the bar or pencil. An adaptation of this test may be employed also for distant vision, a narrow ruler being held at about half a metre vertically in front of the patient's face.

One of the most generally known tests is that of Snellen. It consists of reading a word of alternate red and green letters, seen through transmitted light, the patient wearing a green and red glass before the right and left eye respectively. Letters forming a word, such as the word FRIEND, may be placed in the window with the sky behind it, affording the necessary transmitted light. Care should, of course, be taken that the patient does not know beforehand what the letters are. If he reads both red and green letters he has binocular vision. An adaptation of this test is that of Worth's, which he calls the "four-dot-test." He describes it as follows : " A piece of plain ground glass, 12 inches by 9 inches, is covered on the back with

opaque black paper. The black paper has four round holes cut in it, each 3 inches in diameter, as shown in the diagram (Fig. 6). The lower hole is left clear. Behind the upper hole is cemented a piece of red glass. Behind each of the other two is cemented a piece of green glass. The arrangement is mounted in the front of a box which contains an electric or other bright light. The patient, standing

FIG. 6.—WORTH'S TEST FOR BINOCULAR VISION.

5 or 6 yards away, wears a trial frame with a red glass before the right eye and a green glass before the left. If now he sees two dots (white and red), he is using the right eye only. If he sees three dots (white and two green), he is using the left eye only. If he sees four dots (white, red, and two green), he uses both eyes, and has, at least, Grade I binocular vision. If he sees five dots (red, two green, and two white), he has diplopia. If the accuracy of the patient's answers be doubted, it may be tested by changing the

glasses in the spectacle frame from one eye to the other."

The amblyoscope may be also used for testing binocular vision, as well as for demonstrating the elasticity of fusion and for the exercises in the treatment of squint.

Hering's drop test is an instructive experiment mentioned in detail in most of the text-books. It consists in looking through a box at a bead strung on a thread and telling whether objects are dropped in front of or behind the bead. This test is not infallible, and it is only for the sense of perspective.

CHAPTER IV

THE IMPORTANT WORK OF JAVAL AND PARINAUD

DRS. EMIL JAVAL and PARINAUD, the one in 1896 and the other in 1899, published in Paris important monographs on the subject of squint, and both observers have largely helped towards our arriving at a true understanding of squint cases.

Ever since the year 1847 attempts were made to cure squint by the use of prismatic lenses. The idea of employing prisms seems so natural that it is not to be wondered at that it was brought forward first by Krecke and then by Donders, but it has proved disappointing, troublesome, and, in many cases, impracticable. Javal wrote concerning the idea as follows: "The employment of these glasses should be reserved for a very small number of favourable cases; it is hardly practicable to carry in spectacle frames prisms of an angle of 10 or 12 degrees. . . . Besides, prismatic lenses are only useful with patients endowed with the easy fusion of binocular images." He then goes on to say that "their employment is only excusable when patients obstinately refuse operation." These favourable cases are the very ones that can be most easily cured by other measures, and the prescribing of prisms for squint can hardly be said to come within the pale of modern treatment. I merely mention this antiquated form of treatment to show that men like Javal have worked at it, and with a small measure of success. As we shall see later on, prisms play an important rôle in the management of cases of muscle-balance disturbance. Javal published a paper on the treatment of squint by prismatic lenses in 1863.

In his " Manuel du Strabisme " he deals exhaustively with the subject of strabismus generally, and gives many cases of benefit to children by stereoscopic exercises, and even benefit to the adults who have had sufficient strength of mind to persevere, and who have thus worked very hard at their treatment.

In the introduction to his book Javal wrote : " It is over thirty years ago since I first undertook the cure of a case of squint by means of the stereoscope." He describes this case as follows : " Sophie J——, born on October 9, 1853, was brought, at two years of age, to Sichel, with a convergent squint of the right eye, very noticeable for the last fifteen days ; it had appeared occasionally, at irregular periods, slightly, for a long time." The principal treatment recommended was covering the left eye and exercising the right for objects at a distance ; the avoidance of convergence for small objects close to, small toys, beads, etc., being forbidden. In 1856 the squint had become alternating. Sichel then advised that one eye should be covered as often as the other, each for a few minutes at a time once or twice daily. This proving unsuccessful, Javal writes : " Towards the end of 1863, the child being ten years of age, after an attempt to cure by prisms, made unsuccessfully by Giraud-Teulon, I conceived the idea to try with the stereoscope " (both von Graefe and Desmarres, who had seen the case, were of opinion that it was absolutely necessary to operate). " This awakened diplopia, and in less than six months the child had fairly good binocular vision by means of these stereoscopic exercises. A tenotomy was practised on the left eye by von Graefe in 1869." This case was not very successful, for, in spite of the stereoscopic vision and the operation, she still continued to have a slight alternating squint. Evidently owing to the fusion faculty never having been properly developed in childhood, although stereoscopic vision was obtained, the treatment failed to be completely a success. The result of this case, and what he had learnt by it, however, encouraged Javal to continue. He abandoned his career as a mining engineer to become a medical student, and subsequently he became the pupil of von Graefe. The

works of Donders and Helmholtz were translated by him into the French language; he invented numerous optical instruments, notably the ophthalmometer (or astigmometer); and for many years he pursued a brilliant career as an oculist in Paris, until he became the victim himself of double glaucoma. His work on strabismus was, I am informed, finished under these distressing circumstances, dictating it to an amanuensis, as Milton did his poem of "Paradise Lost." Since then he has published another book, "The Blind Man's World," which gives good advice for blind people. His death occurred in 1906, only last year. The above case has been cited chiefly because of its interesting bearing upon Javal's life.

A much more successful case is the following: "Alfred X——, twenty-one years of age, was affected with a recent divergent squint, nearly continuous, of the left eye. The deviation was not usually marked when he was looking at distant objects, but it was very considerable and constant when he was looking at near objects. He presented himself," Javal writes, "in my consulting-room on March 4, 1894, asking to be healed by the morning of the 15th, before undergoing on that day a medical examination upon which his career depended." He had myopic astigmatism with both eyes, but more especially the right. "In view of the importance of the deviation, I did not hesitate to propose an immediate tenotomy; but we feared that, the trace of the operation not being able to be effaced in eleven days, this intervention would only have the result of drawing the attention of the medical expert to the astigmatism of the candidate. We decided, therefore, to see whether cure could not be brought about by exercises. After eight days of the most arduous work, every trace of the deviation had disappeared, and the young man X—— sent me on the 15th a telegram announcing his admission. He presented himself without spectacles to the medical examiner, and passed without anything being said. I have seen him since. He no longer has any squint, and the binocular reading is kept up; it is understood that he has resolved to always keep to his spectacles for reading." This case shows that

some cases of divergent squint with myopia are curable with stereoscopic exercises.

Some of Dr. Javal's cases had to persevere for years with the stereoscopic exercises, the *lecture controlé* (bar-reading), etc., notably the case of "little Susanne M——," mentioned on p. 162 of his book, who began treatment, when two years of age, in 1879 and finished in 1895. The treatment began with the *louchette* (covering one eye with an opaque shell) until she was three years of age. Then she was neglected, There were two periods of time, one of six years and the other of six months, when the treatment was discontinued, the six-year interval being before she commenced the stereoscopic exercises, which she began when she was about nine years of age. The notes of this case cover several pages of Javal's book. Suffice to say that she arrived at perfect cure without operation, and became a young lady "of very pleasing appearance, without the slightest trace of her former infirmity." I wonder whether any English patients and their friends could be found to submit to seven or eight years' almost continuous treatment by means of orthoptic exercises. Another interesting case is that of young Maurice Degeorge. Javal relates it as follows: "In August, 1880, a boy of eleven years of age was brought to me, Maurice Degeorge, affected with a convergent squint of the left eye since two and a half years of age. When the right eye was covered the left eye had no fixation. Under these circumstances, I explained to the father that the re-establishment of binocular vision was very unlikely. I related to him cases, taken from several authors, of squinters who, having lost the good eye by accident, the remaining eye continued to deviate, in spite of the permanent exercise to which it was forcibly made to submit, never becoming straightened. The father, however, persisted, and asked me whether it were not within the bounds of possibility theoretically to hope for the re-establishment of sight to the son's eye. Certainly, I told him, the loss of fixation being the consequence and not the cause of the strabismus, it was still possible, taking into consideration the youth of the patient, that the sight of the left eye might be re-

established by the occlusion of the sound eye ; but that was never practised (*i.e.*, when fixation is lost), and I did not dare to suggest such a punishment to his son, without being perfectly certain as to the result. The father then said to me that science could not be advanced without sacrifices, and he offered his son as a victim. I accepted, and we decided that during the two months of his holidays the youth should wear constantly an opaque shell over the right eye. For an hour a day, in order to read, he should be permitted to put the shell over the left eye.

"Two months after the left eye was somewhat straightened, but in an undecided sort of way. The youth went back to school, wearing constantly his *louchette,* but with the permission to put it over his left eye during his work. During the Christmas holidays the left eye was sufficiently improved to permit the refraction being measured, and a spectacle lens was prescribed for this eye, correcting the astigmatism (+2·5 *Cyl.* ax. vert.). But the visual acuity was still only moderately good. A slight refractive error of the right eye had also been prescribed for.

" A year after the commencement of the treatment, tenotomy was performed, followed by stereoscopic exercises every day for fifteen days. After the summer holidays in October he was allowed to go to school regularly, three days before going having performed the stereoscopic exercises each day. *The visual acuity of the left eye had become equal to that of the right.* In the Easter holidays we finally allowed him to keep his two eyes uncovered, both at the same time, while wearing his spectacles." The above case is cited, not as one that did not need operation, for tenotomy had to be performed for the final readjustment of the deviation, but as one where lost fixation and amblyopia was cured by exercising the affected eye.

Dr. Javal's book abounds with cases, some having operative treatment as part of the cure, and others being cured without, much depending upon the patience and perseverance of the patients and their friends. At first he invariably used the stereoscope, but in later years he supplemented the treatment with bar-reading and other visual exercises

apart from the stereoscope. When there existed in a patient affected with diplopia a point of view where the fusion of images was obtained by holding the head in a certain position, he was able to undertake to extend by exercises this single vision in all directions. The two stereoscopes principally used by Javal were his *stéréoscope à cinq mouvements*, which he had constructed, assisted by Dr. Bull, who worked with him for a number of years, and the *stéréoscope à charnière.* This latter has no lenses, and is a device of two mirrors, which can be moved to different angles by means of a hinge, the cards being reflected in

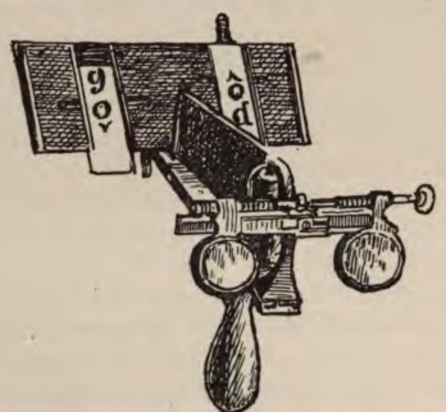


FIG. 7.—THE FIVE-MOVEMENT STEREOSCOPE OF JAVAL AND BULL. (Showing Javal's K 13 cards.)

the mirrors. Javal's stereoscope with five movements is an ingenious but rather complicated instrument. It is shown in Fig. 7. Holmes' stereoscope is the ordinary American pattern, sold by Curry and Paxton in this country; it is inexpensive and does well for routine work. Worth's instrument is the best for training the fusion faculty.

Javal theoretically divided his treatment into three parts: the first was devoted to making diplopia reappear; the second to blending, if possible, the images by means of stereoscopic exercises; the third to consolidating the result obtained by re-establishing the correct relationship between convergence and accommodation.

With regard to the use of the hinge and mirror stereoscope, Javal writes : " In spite of the care that has been taken to increase the field of the stereoscope by the employment of lenses of relatively short foci, it often happens that the deviation is too strong to enable one to use a stereoscope which has lenses at all. It is then that one finds the advantage of employing my *stéréoscope à charnière.*"

It has undoubtedly been upon this pioneer work of Dr. Emil Javal that much of the modern non-operative treatment of squint has been founded. This will be fully described in Chapter VII.

Parinaud fully recognizes the importance of the fusion faculty in the etiology of convergent squint. He says there is an unusual adaptation in ametropia, which is cerebral, of the convergence and the accommodation. This fails in some cases of hypermetropia, but is it not the rule for it to fail, it is the exception. There is this new adaptation because the fusion faculty becomes developed, and although the error of refraction, of course, continues, no squint takes place. The hypermetropic eye remains hypermetropic, and it is very exceptional to see the degree of hypermetropia become modified, except it be, in after-life, by senile alterations in the crystalline lens.

Many observers have pointed out that the occlusion of an eye in a child for some time—*i.e.*, two or three months—has resulted in a permanent squint. The child has been found to squint when the bandage was taken off, although the inflammation for which the bandage had been used had not left behind the slightest opacity of the cornea or appreciable alteration in the vision. Parinaud remarks that the influence of prolonged occlusion of an eye in developing squint is not incompatible with the usefulness of temporarily occluding an eye in the treatment of the same affection, an occlusion which has as its object the development of the visual acuity of the squinting eye by forcing it to maintain fixation. He believes in cerebral causes having much to do with squint, and he mentions hereditary syphilis as a possible contributing factor.

Although in a few cases of squint the amplitude of accom-

modation is altered relatively in the two eyes, it is the rule, as has been pointed out by numerous authors, that with squinting children this amplitude remains the same. In fifty cases examined on this point by L. Weiss only about nine showed an insufficiency of amplitude in the eye that squinted, six of them being convergent cases and three divergent.

Parinaud does not display much enthusiasm for the operative treatment of strabismus. He says : " We employ operative measures without assurance, without certainty of result. The same measure succeeds with one squinter which fails with another without one very well knowing why. A tenotomy performed for the same degree of deviation, and to all appearance in like conditions, produces different results without anyone being able to tell the reason for this difference. In addition, the remote results of an operation have often come as a disappointment, and destroyed the satisfaction that has been felt at the immediate results. Also, in spite of the claim many times asserted of being able to reduce the treatment of squint to the proportion of a simple problem of mechanics and of regulating, at will, the effect of the operation, the question is always coming up, and we are constantly modifying our proceedings. 'It has been,' said de Wecker, 'a sort of shuffling from pillar to post for the last twenty-five years, and even for longer than that.' One is not surprised at this uncertainty when one is enlightened on the nature of strabismus and on the variety of influences that are brought to bear upon it."

He sums up the various pathological factors, one or more of which may have been the cause or causes of the deviation in any given case, interfering with the establishment or re-establishment of binocular vision. They are six in number, as follows :

1. The influence of accommodation, excessive or the opposite.

2. Alteration of the reflex of convergence and of the function of fusion.

3. A more or less definite alteration of the innervation of convergence.

4. The retraction of the fibrous aponeurosis (Tenon's capsule).

5. Secondary modifications of the muscles.

6. Modifications of the sensorial functions.

Parinaud observed that with myopic cases of convergent squint concave glasses sometimes diminish the excess of convergence ; this is a curious fact, since by the accommodative effort which they impose they ought to increase it.

It is explained by the fact that the concave glasses causing the far point of accommodation to recede also causes the far point of convergence equally to recede, so that the excess of convergence is at least diminished when the eyes are at rest.

As to treatment, Parinaud recommends the full correction of any error of refraction, especially in anisometropia. He believes that prisms may be useful in a certain number of cases, and he also recommends an attempt to re-establish binocular vision by exercising what power of fixation the deviating eye still happens to possess. This ameliorates the visual acuity of the affected eye, and it is accomplished by the occlusion of the sound eye (see Chapter VII.). To establish binocular vision he recommends exercises with the stereoscope, as stereoscopic vision is a long way towards natural binocular single vision. "It acts," he says, "by means of a particular arrangement which solicits binocular fusion in an abnormal manner." Stereoscopic vision is an artificial—*i.e.*, abnormal—kind of binocular vision ; it is obtained by means of images that are virtual, the result of false projection ; that is to say, they do not correspond to the position in space of the actual figures that have caused them. This is explained by the diagram (Fig. 8). It especially differs from normal binocular vision in that it does not necessitate the employment of convergence, which is indispensable for natural binocular vision. The great difficulty with cases of squint is that even when you have succeeded in establishing stereoscopic binocular vision, because of convergence having become, more or less, permanently altered, it frequently happens that they never obtain

natural binocular vision, even although operations may have, to some extent, straightened their eyes.

The details of the stereoscopic exercises recommended are

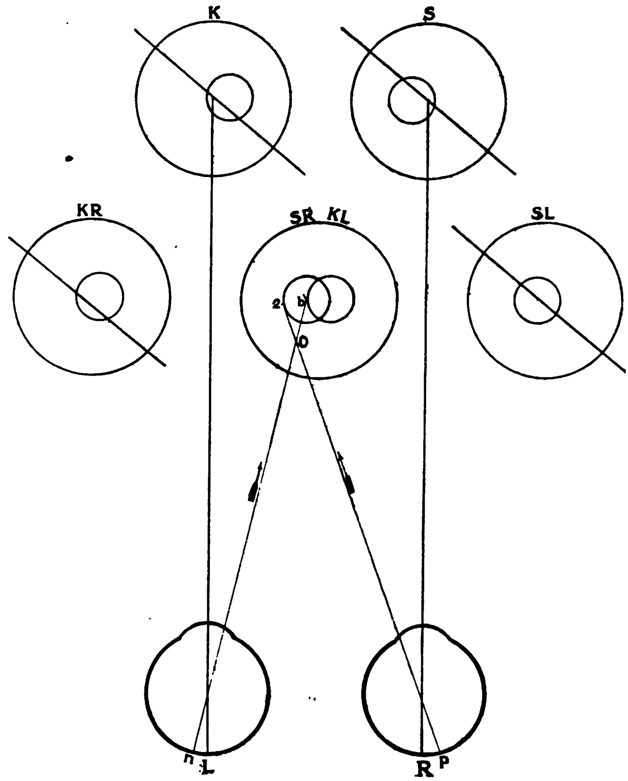


FIG. 8.—DIAGRAM OF STEREOSCOPIC VISION (PARINAUD).

R, Right eye; *L*, left eye; *S* and *K* are the stereoscopic figures giving by their fusion the sensation of a truncated cone; *KR* and *SR*, images of these two figures which are projected by the right eye; *KL* and *SL*, images of these two figures which are projected by the left eye; *p*, *a'*, axis of projection of the point *a*; *n*, *b'*, axis of projection of the point *b*; the oblique lines indicate that it is necessary to take away the figures *K* and *S*, as well as their images *KR* and *SL* (suppressed by the partition wall of the stereoscope), to only take into consideration *SR* and *KL*, virtual images, which by their fusion in space give the stereoscopic vision.

not necessary to dwell on. Most of the cards are numbered and lettered according to the simplicity or complexity of the figures, and the facility or difficulty of fusing their

images. In Javal's set of cards he commences with larger figures, big letters, circles, large arrows, etc., then goes on to smaller figures, and lastly to reading type, with black bars, etc., across to make the types more difficult to blend. The C card is a useful one; it consists of the two letters F and L, which blend together in the stereoscope to form the letter E. One of Javal's K series, shown as a divided card, is represented in Fig. 7. It is the small letter *g* above small *o*, on the left, and small *d* below small *o* on the right, the two small *o's* are blended to form one in the stereoscope forming the word " god," the letters placed vertically and having a small arrow-head, above and below, so that seen properly in the stereoscope it would look like this:

g
o
d

This is a sample of the kind of devices Javal used to solicit stereoscopic binocular vision.

Parinaud devised an excellent stereoscope with a series of cards. He says:

" We can make stereoscopic vision easy in three ways.

" First, by convex glasses, the action of which is most important. Convex glasses facilitate the relaxation of convergence, in relaxing the accommodation; moreover, they allow of having clear images of stereoscopic figures brought near to one another, with an adaptation of the visual mechanism for distant vision. In the original stereoscope of Wheatstone (the inventor) lenses are not so necessary, because the images happen to be separated by the reflection of mirrors.

" Secondly, by prisms, bases outward. These produce crossed diplopia; in other words, they modify the position of the images on the retina in such a way as to relax the convergence. Thus they facilitate this relaxation.

" Thirdly, by making the stereoscopic figures subtend a larger angle of separation from each other, which should act the moment diplopia is produced, by facilitating the fusion in space of those two virtual images that are used for stereoscopic vision " (see Fig. 8).

Parinaud's instrument combines these three modes of

action, and also allows of their being used separately; he claims a great advantage in this way. Worth's amblyoscope also combines these three modes of action, which makes it a very serviceable instrument, besides having a great advantage over Parinaud's in that strong transmitted light through the figures reawakens the sensitiveness of the neglected retina. Parinaud's stereoscope is an interesting one. He has two large square lenses, which give an extensive field, with two large square prisms on each side of the frame in which the lenses are placed; these move in such a way that they can be placed in juxtaposition to the lenses or taken away from them altogether. By removing the middle partition, taking away the lenses, and putting the prisms with their bases inwards, he can turn the instrument into what he calls a "pseudoscope." This is useful in exercising the sense of *relief* (perspective). The effect is to change a figure, such as a tub, upside down, so that it looks hollow; what was before the foreground is now the background, and *vice versa.* It reverses the stereoscopic relief sensation. In Fig. 8 we have a' and b', points of the two small circles a and b in the actual figures on the card in the stereoscope. With proper fusion sense (Worth's third grade), where there is a' and b' in the diagram should correspond, so that only one small circle is seen, the two are blended into one; the points p and n are so nearly corresponding in relative position on the two retinæ that they ought to be one point psychically, appreciated by the brain as if situated at o, where the lines cross; this gives the idea of perspective or relief. The pseudoscopic effect would be the reverse—the small circle would recede and the large one would come forward, so that instead of looking on the top of a truncated cone, it would be like looking down into a hollow. It is the perfection of stereoscopic vision when both of these effects are produced, vision is as perfect as the stereoscope (or the pseudoscope) can make it. Wheatstone invented a pseudoscope, the obverse to the stereoscope, as a separate instrument, reversing as above explained what is termed the "stereoscopic parallax"; this does not seem to be at all well known. Pseudoscopic exercises are an excellent way

of strengthening the convergence. Parinaud's instrument can be obtained of Giraud Fils et Cie, opticians, Rue l'École de Médecine, Paris. It is an excellent one for those who can afford to buy an expensive instrument.

A new form of stereoscope, of quite a simple pattern, has recently been brought out by Messrs. C. W. Dixey and Son, London. It is inexpensive, and the power of the lenses and prisms has been carefully calculated, the former being adjustable to the interpupillary width of the patient. This may prove a serviceable instrument for some cases, more especially for home use. Kroll's pictures are used with this stereoscope; they are excellent for children, as they are coloured and there is a good variety of them.

CHAPTER V

THE QUESTION OF AMBLYOPIA

AMBLYOPIA may be defined as partial blindness of one or both eyes, this blindness chiefly consisting in loss of central vision, and persisting after any error of refraction has been corrected. Nothing abnormal can be seen to account for the blindness either in the fundus or in any of the media of the eye ; it is purely functional—*i.e.*, subjective—in character.

According to Schweigger amblyopia in squint is congenital, but the more generally accepted opinion has been that it is acquired from disuse of the squinting eye. Swanzy, in former editions of his book, seems to have favoured Schweigger's view ; but I see, in his latest edition (*loc. cit.*), he has rather modified this opinion, and seems to be more in accord with the views of Priestley Smith and Worth. There is not the slightest doubt that in some of the cases of strabismus amblyopia is a cause ; but, on the other hand, in the majority of cases it is undoubtedly the result. Of course, when there really is, for any reason, congenital defect of the vision of one eye sufficient to cause strabismus, development of the fusion faculty naturally is interfered with and may be altogether prevented. Squint, therefore, is bound to occur as soon as convergence and accommodation begin to be called into action. Swanzy states that cases of congenital amblyopia of both eyes are not uncommon, and that it is still more common to meet with congenital amblyopia in one eye. In making this statement he is including all cases thought to be congenital amblyopia, whether accompanied by squint or not. On the other hand, Worth writes : " Apart from squint, congenital

amblyopia is very seldom met with. One should not accept a case as being one of congenital amblyopia unless careful questioning of intelligent and observant parents makes it certain that the patient has never squinted as a child." He says that " in the course of examining the refraction of many thousands of patients, who have never squinted, he has only met with twenty-three cases of amblyopia of $\frac{6}{18}$ or higher, which he has felt justified in regarding as congenital." If congenital amblyopia were a common cause of squint, infants would commonly be noticed to squint in an unmistakable manner soon after birth, but this is not the case. Infants are frequently noticed to apparently be going through a period of ocular indecision, but the keenest observer cannot be quite sure whether a young infant is squinting or not. This is the period before fixation and before the development of the fusion faculty. Of course, when there is some explanation or obvious reason for a squint at birth, such as traumatism from instrumental delivery, this is another thing ; but even these cases are infrequent ; they may be paralytic from the pressure, and, as Bickerton points out, the retina having been slightly injured, the result is amblyopia. The effect of the injury clears up, so that the retina looks normal, but the partial blindness remains to be classed as a case of congenital amblyopia by the ophthalmic surgeon later on, the history being that the child has always been blind in one eye and has squinted with it from birth. No inquiry is made about the manner in which delivery had been brought about, whether labour was prolonged or whether instruments were used, and the surgeon rests contented with his diagnosis of congenital amblyopia, not asking himself why it should be congenital. A few cases I have met with, believed to be congenital amblyopia, have had no squint at all, although the amblyopia, in association with pronounced astigmatism, has only affected one eye. The other, without astigmatism, has had excellent vision. Other cases, again, have been congenitally amblyopic with both eyes, but this is rare, and in every instance one eye has better vision than the other. In just such a case recently I managed, after

considerable trouble, to bring the vision of the right eye up to $\frac{6}{18}$ and the left eye up to $\frac{6}{9}$. In all these cases there is a perfectly normal field of vision, and the visual acuity is never less than $\frac{6}{60}$. Cases of mixed astigmatism have presumably some congenital amblyopia if their accurate correction has not improved the visual acuity beyond $\frac{6}{18}$.

In many cases which appear to be congenitally amblyopic the correction of the refractive error does not immediately improve the vision, but after persevering with the glasses for a longer or shorter period, improvement gradually takes place, so that the visual acuity may finally reach the normal. These cases surely are those of retinal asthenopia, and this accounts for the diversity of opinion amongst observers, many of whom state that congenital amblyopia is of common occurrence.

Patients do not invariably return to tell the surgeon that the vision has improved; they take the improvement of their sight as a matter of course; like the ungrateful lepers in the Bible incident, they do not turn back to give thanks. Where there is the presence of a coloboma, or other congenital abnormality, the likelihood of its being a case of congenital amblyopia is certainly increased. In cases where both eyes are congenitally amblyopic there is almost invariably nystagmus. Congenital defect of vision is attributed to imperfect development of the finer parts of the retina.

The question of amblyopia in the squinting eye is certainly a difficult one. It may be often found in a marked degree in a child's squinting eye, while in adults the eye that squints frequently has the better vision. There are also the cases of eccentric fixation—that is, on covering the fixing eye, the squinting eye, instead of becoming straight and fixing, rolls in all the more, and, again, in other cases, there is an uncertainty of fixation; no part of the retina seems of any use for fixation. This latter condition is undoubtedly the result of the strabismus, and it is characteristic of the acquired form of amblyopia (amblyopia ex anopsia).

There are quite a number of terms used for this acquired

form of amblyopia besides "amblyopia ex anopsia." It is termed non-toxic amblyopia, to distinguish it from the toxic acquired loss of visual acuity (commonly the result of tobacco), argamblyopia, etc. They all mean partial blindness of an eye from neglecting to use it. Putting on one side cases that have arisen from an opacity in one of the dioptric media, the vast majority appear to be the result of squint. One great argument in favour of the amblyopia ex anopsia theory is the fact that, in a large number of cases, improvement of the vision takes place in the squinting eye by systematic separate use. It may even be brought up to normal vision. This surely puts the idea of congenital amblyopia, in such cases, entirely out of court. Improvement may even take place in vision after a tenotomy, simply because the squinting eye is more exercised after the operation than before. But straightening (by operation) an eye cannot be relied on for improving its vision, since it is well known that this does not take place through operation only, and the eye has to have its vision developed by separate use. It is the using of the eye that improves its vision; the operation only indirectly influences the vision by placing the eye in such a position as to render its use a possibility. On the other hand, separate use may altogether fail in improving vision, and it is these cases which should be regarded as the ones that are truly congenital.

Schweigger's argument that the cases which improve are those in whom defective vision is due to retinal asthenopia seems to be altogether begging the question. Why should a young child have good vision in one eye and retinal asthenopia in the other? If the eye that has the "retinal asthenopia" be neglected, not only squint, but pronounced amblyopia, results.

The theory of defective development of the faculty of fusion is upheld by Priestley Smith and a number of other leading authorities. The faculty is acquired and developed, as I have endeavoured to explain (Chapter II.), during early infancy. The amblyopia ex anopsia view harmonizes with this theory of fusion faculty development. If the faculty

become well developed, amblyopia from disuse of an eye is a physiological impossibility. On the other hand, squinting eyes in early life (before the faculty is properly developed) have started with perfect vision. This vision is lost through neglect, and the eye becomes very blind in the central part of the visual field. No theory of retinal asthenopia can account for this fact, and these cases, beginning with good vision of the eye, are obviously not congenital.

Squint comes on usually at about three years of age, and visual suppression of one or other eye begins at the same time as the squint commences. In 73 per cent. of the cases mentioned as having been observed by Priestley Smith, the onset of the squint began before five years of age. When an infant develops a squint, the supervention of amblyopia is extremely rapid. The squinting eye, at the very onset, is seen to have good vision, then in a few weeks the eye is amblyopic and fixation becomes lost. When a child is about eighteen months old at the onset of the squint, the amblyopia occurs in about six months. At three years of age, more than a year supervenes before vision has gone in the squinting eye and loss of fixation is observed. After six years, when an eye commences to squint, amblyopia seldom supervenes to any great extent. It is the squint that causes the amblyopia in these young children (under six years), not the amblyopia the squint. The latter has other causes beside squint, such as the disuse of the eyes through long continued blepharospasm; here it is double, and merely bandaging one eye for a considerable time will cause it.

Out of thirty cases recorded by Worth only one under twelve months was found to have a vision in the squinting eye of less than $\frac{6}{12}$. It is obviously untrue to say that the squinting eyes of infants are necessarily blind, and those who have opposed the theory of amblyopia ex anopsia are shown to have been mistaken in considering the defective vision of an eye to have commonly arisen in squint from some congenital abnormality.

CHAPTER VI

CONVERGENT SQUINT: ITS DEFINITION, CONDITIONS, CAUSATION, CLASSIFICATIONS, AND INVESTIGATION

THE axis of the deviating eye is directed inwards (internal strabismus). Parinaud defines squint as "an error of development of the organic arrangement of binocular vision hindering the eyes from properly converging on the object that is fixed." This seems a fairly satisfactory definition, so long as we clearly keep in mind the fact that comitant squint is functional and not mechanical. It is a functional lack of development. The French oculist is right in saying that two fundamental errors have, in the past, falsified our ideas on the nature of squint—one has been that of attributing the deviation of the eyes simply to a muscular abnormality, the other has been the identifying squint with this deviation. The deviation is merely a symptom; a single symptom has been mistaken for the whole disease. One might as well describe Pott's disease as "a deviation of the spine from its normal shape." Even so great an authority as Fuchs, in his latest edition of his text-book, defines squint as follows: "Squint consists in a deviation of the visual axis of one of the eyes from the correct position of fixation upon an object, the deviation occurring in every direction in which the eyes are turned and always through the same angle." This is an excellent description of the most noticeable symptom, but it is far from being a definition of the disease. He goes on to say: "Squint is thus distinguished from paralysis, of which, on

the one hand, the deflection is present only in the sphere of action of the paralysed muscle, and, on the other hand, when once within the limits of this sphere, it becomes greater and greater the farther the eye is carried into the latter, because then the paralysed eye lags more and more behind the sound one. A squinting eye, on the contrary, does not lag behind the other in any direction in which the eyes may look, but accompanies it in all its movements, and always deviates to the same degree from the correct position, for which reason squinting is known as strabismus concomitans" (Fig. 12). The above description is excellent if we only take into account the outward appearance of a squint case, that which can at once be seen by the surgeon the moment the patient enters his consulting-room or comes before him in the out-patients' department of a hospital; but the essential nature of squint is much more profound, and the differences between a case of squint and one of paralysed eye are more and greater. There is the question of vision in both kinds of cases, and especially is there the question of binocular vision to be taken into account. Because such a condition as ocular paralysis exists in its various forms, presenting the appearance of a deviation looking like squint, too much attention has, in all cases, been directed to anatomical conditions, real or imagined, to the obscuring of true pathology. Strabismus, or squint, is in all respects, except that of casual appearance, totally different from paralysis, and, indeed, it has far more to do with the partial monocular blindness, termed amblyopia, than with any anatomical peculiarity of an ocular muscle. As regards convergent squint, a more accurate definition may be given, as follows: "A lack of development of the faculty of fusion which interferes with the organic arrangement of binocular vision, and causes a deviation of the visual axis of one of the eyes from the correct position of fixation. Stevens in America gives the name 'heterotropia' to all cases of strabismus or squint, and William Zentmeyer of Philadelphia defines the term as 'a deviation of the two visual lines from parallelism in such a manner that they cannot habitually be united at the same point of

fixation.' " I do not agree with this. In my opinion it is better to reserve the term " heterotropia " for a very distinct and rare condition which has nothing whatever to do with ordinary squint, which, indeed, is neither a true squint nor yet a paralysis. Heterotropia is a deviation that occurs as a further stage of heterophoria (*vide* Chapter XV.).

The Conditions of Convergent Squint.—The two essential conditions of every case of comitant convergent strabismus are :

1. A defect of the faculty of fusion.
2. An abnormal convergence of the visual axes.

There are other conditions associated with or arising from the above ; they are as follows :

1. The eye that is not used for fixation has its vision suppressed, which suppression continues on to absolute central amblyopia, as the result of neglect or inefficient treatment.

2. Congenital amblyopia is certainly a fact, but the cases are somewhat rare.

3. There is usually some error of refraction, and this is generally hypermetropia or hypermetropic astigmatism.

Classification of Squint.—As a rule, we find squint classified according to the nature of the deviation, the two main varieties being convergent and divergent. The divergent varieties will be conveniently considered in a subsequent chapter. Convergent strabismus is either—

(1) Unilateral or alternating ;
(2) Manifest or latent ;
(3) Permanent or intermittent.

But there are other methods of classification besides the above, which are useful to bear in mind from the point of view of prognosis, and therefore having some clinical value. They are given by Javal, and are as follows :

1. *Classification according to the Amount of Binocular Vision still remaining in any Given Case.*—If there still is some slight amount of binocular vision, an attempt at

cure by orthoptic measures is easier than where it is entirely absent. "If," says Javal, "there remains for a few seconds at a time, and for a point of view, whatever that may be, a vestige of binocular vision, our task is limited to extending this vision, which is relatively easy; whilst, on the other hand, with patients that squint in a permanent manner, and with whom, no matter what may be the direction in which they look, it becomes necessary to entirely reconstruct binocular vision, the undertaking (of successful orthoptic measures), although rarely absolutely impossible, greatly exhausts the patience even of the best of the patients."

2. *Classification according to the State of the Eye that habitually deviates.*—When it is a case of strictly unilateral strabismus, it becomes necessary to pay particular attention to the way in which the deviating eye is working, since the prognosis will be altogether different according to whether we find this eye is able to straighten itself or not when the other one is covered. We may therefore classify these cases as follows:

(*a*) Cases where fixation of previously deviating eye is at once taken up and is easily maintained.

(*b*) Cases where on covering the straight eye the fixation is only imperfectly taken up, and is not maintained by the previously squinting eye.

(*c*) Cases where all fixation of squinting eye is impossible. These last are, of course, the most unfavourable of all.

The Etiology of Convergent Squint.—Various unscientific and sometimes absurd causes are given by the laity as explanations for a child squinting. Amongst the more educated upper classes an unfortunate nursemaid is blamed, unjustly accused of "making the child squint." It is the injustice of ignorance. Again, a supposed wrong position of the cradle relative to the light has been thought, even by medical men, to have had something to do with the causation of squint; and, again, the child has been thought to have imitated the squinting of a little playmate, or the habit is supposed to have been acquired by constantly staring at some object fixed very near to one eye, such as a curl, or the curtain of the bed hanging close by. Other

curious but quite common ideas, as old as medieval times, and perhaps even older, are that it is due to witchcraft, an evil disposition of the child, mental defect, fright, whooping-cough, naughtiness, etc. Every one of these ideas in the light of modern science is manifestly and utterly wrong. I have known parents who have bitterly blamed themselves for leaving their children to the care too much of servants, imagining that it has been possible for the servants to have "wickedly amused themselves in making the child squint," and it has been difficult to persuade them such regret is unfounded so far as the causation of squint is concerned. The essential cause of common squint is a defect of the fusion faculty. Anything that hinders this faculty from developing will help towards the causation of convergent squint, and anything that upsets the equilibrium of the convergence centre, whilst the fusion faculty is only weakly developed, will become its exciting cause. The reason why the fusion faculty may remain undeveloped or be only partially developed is the presence of some congenital predisposition or weakness. In most of the cases there exists more or less hypermetropia, but this can only act as an exciting cause when the fusion faculty remains undeveloped, as it is a well-known fact that there are large numbers of cases of every degree of hypermetropia, both with and without astigmatism, where there is not the slightest tendency to squint. In hypermetropia there is a disturbance of the balance between accommodation and convergence. If the fusion faculty is well developed, the desire for binocular vision counteracts this disturbance, and there is no squint; but if, on the other hand, the faculty is lacking, there is no desire for binocular vision, and hypermetropia acts as the exciting cause of squint. There is no doubt that diplopia is present very faintly at the first, but it is soon disregarded. The vision of the squinting eye is, so to speak, neglected by the brain; in other words, there is suppression which goes on to amblyopia from disuse (amblyopia ex anopsia). Normally the internal rectus is slightly the stronger muscle, and there may be some congenital lack of power along with this absence of desire for binocular single vision In rare

cases there is congenital amblyopia. Some are due to injury of an eye by the pressure of instruments at the child's birth. This may even cause what is supposed to be congenital amblyopia. Other causes are the presence of opacities (leucomata) of one cornea, etc.

The Investigation of a Case of Squint.—Every case should be investigated systematically. When a case of convergent squint first comes before you, it is of great advantage to obtain a few important points concerning the patient's history. The time will surely not be grudged when it is remembered that, in cases which are presented early enough, the patient's whole future career may depend upon the skill and care of the surgeon who first sees the case. As regards the history, the points to be elicited are: (1) The age of onset. Sometimes this can be fixed by reference to some family event. (2) The mode of onset—*i.e.*, whether it was constant from the first, or began as an occasional squint. (3) Any illness immediately preceding the onset. (4) Evidences of heredity, such as squint in brothers, sisters, or parents. The case should then be investigated directly, the character of the squint determined, the power of fixation of the deviating eye determined, the dynamic convergence, the movements of each eye separately, the visual acuity of each eye, the condition of the fusion faculty, etc. Most of these points can be at once arrived at by simple inspection, and by covering first one eye and then the other, the patient being asked to look at some object that is moved in front of him. To investigate the fusion faculty it is necessary to use Worth's amblyoscope, or, if there is vision in both eyes, one or other form of stereoscope. In order to obtain an idea of the little patient's visual acuity, Worth recommends ivory balls, easily seen because white in colour and of various sizes. These are to be thrown across the room. The child's fixing eye having been covered over in some way, he is told to go and fetch the ball when it has stopped rolling. A convenient way of covering the fixing eye is by means of a silk handkerchief. Some allusion to blind-man's buff will enable the eye to be bound up, the whole thing being tactfully presented to

the child's mind as a game. Begin with the largest ball, corresponding to Snellen's type D = 60, and then go on to the smallest. The balls should be made accurately to scale, or as nearly so as possible. I find ordinary hollow rubber balls painted white answer equally as well as the ivory ones, which latter are expensive. To prevent so much running about the room a child may be shown a card similar to a test-type card, on which, in place of the letters, are represented familiar objects brightly coloured, such as trees, animals, trains, toys, etc. I have lately devised such a card of these type-sized pictures, with a blind, which is drawn up by means of a cord from the other side of the room. The child is immensely taken with the gradual uncovering of these pictures, and the moment he sees them will point and say, "Gee-gee," "Baa-lamb," "Puff-puff," etc., as they are revealed to his view. Of course the more important thing is to determine the vision of the squinting eye, but if the surgeon has plenty of time to spare, it is well to find out also the vision of the supposedly good or fixing eye. This may be quickly done by the hand being placed over its fellow, the child being on the surgeon's or the nurse's knee. To find the separate movements of the eye a silver ball, suspended by an elastic cord may be dangled in different directions before the child's uncovered eye, covering first the one eye and then the other. This is a better plan than that of making the child regard the surgeon's finger, an object far less interesting to his baby mind. The dynamic convergence is estimated by bringing the interesting object nearer and nearer to the fixing eye, the surgeon keeping himself at an arm's length away.

Having determined these preliminary points of immense value, we now proceeed to measure the angle of the squint. This can be done in a number of ways. The usual way of doing it is either by means of Maddox's tangent scale, or else by means of the perimeter; but I believe the best way of all, especially in young children, is by means of Worth's deviometer. This instrument is made by Messrs. Bonnella and Son, 58, Mortimer Street, London, W., and when fitted up is exceedingly convenient. It has

rather a disadvantage in needing a specially made electric lamp.

The following is Mr. Worth's own description of it : "A wooden stand (made by an ordinary carpenter), about 10 inches high, supports a horizontal wooden arm, 2 inches wide, ¼ inch thick, and about 2 feet long. This arm is pivoted at the end, so that it may be swung over to either side as required. The arm is painted black in front. On the back is a scale of tangents to degrees at 60 centimetres' distance. A flat, hook-shaped piece of brass, having a white

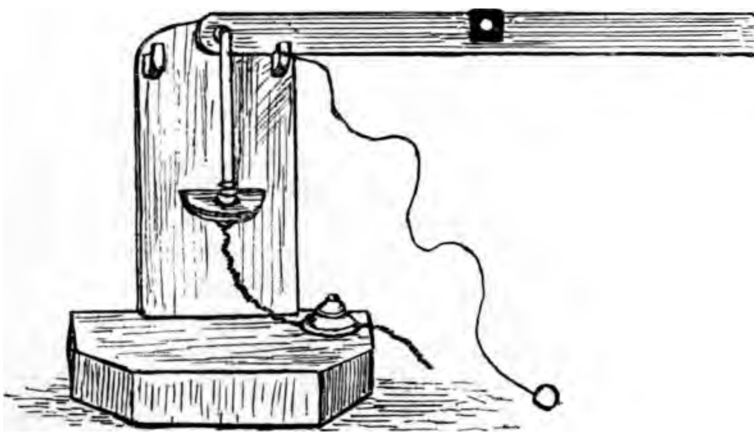


FIG. 9.—WORTH'S DEVIOMETER.

spot on it, slides along the arm. In front of the pillar, below the zero of the scale, is a specially made electric light, 5 inches high and ⅜ inch in diameter. Flexible wires go from the electric lamp to the wall-plug. An electric bell-push is used instead of a switch, so that by pressing the button the light may be flashed off and on very rapidly. A string, 60 centimetres long, is attached to the upright pillar of the instrument. At the end of the string is a ring. The instrument is put on a table. The nurse sits at the table with the child on her knees. She puts the ring on her finger, and holds the child's head steadily with her hands, keeping the string taut. The surgeon 'sights' the child's eyes through the nick in the top of the stand, and presses

the button. The child immediately looks at the light with his fixing eye. The reflection of the lamp forms a vertical line of light on the cornea of his eye, which shows the correct position of fixation. The position of the line of light on the cornea of the squinting eye enables a good guess to be made as to the angles of the deviation. The light is discontinued. The brass traveller, with the white disc, is slid along the arm to the position which corresponds to the guess. The brass traveller, being tapped with the finger, the metallic sound causes the child to look at it. If it does not, a lighted match held in front of the traveller will always attract his attention. The button is then pressed, and the light flashed on for an instant. If the line of light on the cornea of the squinting eye is in a corresponding position to that which it formerly occupied in the fixing eye, the angle of the squint is read off on the scale at the back of the arm. If not, the traveller is moved a little, and when the child looks at it the light is flashed on again, and so on until the true position is found. An older patient can, of course, sit at the table and hold the string himself, and look at the zero of the scale or the white disc on the traveller, when directed to do so."

Squint can also be measured by any one of the following methods :

1. The cover or screen test.
2. Hirschberg's mirror test.
3. Priestley Smith's tape.
4. The Maddox tangent scale.
5. The perimeter.

1. **The Cover or Screen Test.**—This may be resorted to first of all. It consists in telling the patient to look at a small distant object ; then the "good" eye is covered by means of a card, and the squinting eye is invited to continue the fixation of the object. A small ivory instrument, called a strabisometer, is gently placed in front of the lower eyelid, with the zero mark accurately below the centre of the pupil of the uncovered eye. The screen is now removed from the "good" eye, which again takes up the fixation

of the object that is looked at, the squinting eye turns back to where it was before, and the amount of deviation can be at once read off. It only gives a linear measurement. This test is of value in determining the length of the piece of muscle desirable to remove in a high degree of squint

FIG. 10.—HIRSCHBERG'S MIRROR TEST, SHOWING CONVERGENT SQUINT OF LEFT EYE.

The two points of light *a* and *b* are seen thrown by the mirror on to the child's eyes; the point of light is in its right place, *a*, on the fixing eye, but abnormal in position *b* on the other eye, revealing the squint; its position with regard to edge of cornea, edge of pupil, etc., enables the angle of deviation to be roughly estimated.

when an advancement with resection of the muscle is performed; but, as Landolt points out, it is unscientific to speak in linear terms of an angular quantity.

2. **Hirschberg's Test** can also be done with a candle, as well as with the concave mirror of the ophthalmoscope, or retinoscope. The amount of strabismus is estimated from the position of the tiny reflections of the light on the two

corneæ. The patient is in the dark room, and the light of the mirror or the candle is flashed first on the fixing eye and then on the squinting eye. Owing to the angle gamma this reflection of the light or image of the mirror in the fixing eye is usually seen to the nasal side of the centre of the pupil, and the reflection or image in the squinting eye is seen to be somewhere between the centre and (in convergent strabismus) the outer margin of the cornea. Hirschberg estimates that this reflection or image, if seen at the corneal limbus, shows a divergence of about

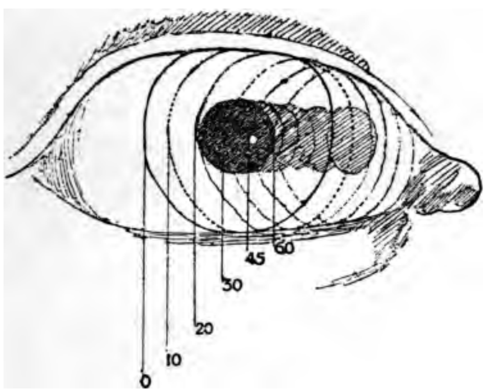


FIG. 11.—CONVERGENT SQUINT OF RIGHT EYE: HIRSCHBERG'S MIRROR, AND OTHER TESTS.

This diagram shows the reflection of a light cast on the cornea and its relative alteration in different degrees of squint.

45 degrees; if it is on the sclera, it is 60 degrees to 80 degrees; if midway between limbus and margin of an average-sized pupil (*i.e.*, 3 to 5 millimetres), it is about 15 degrees to 20 degrees; at the edge of the pupil, 10 degrees, etc. Thus, with practice, a fairly good guess can be made. Allowance is made for the size of the angle gamma, which is estimated by the position of the reflection in the fixing eye; this is subtracted from the above figures if, as is generally the case, the angle is positive—*i.e.*, the light is seen to the nasal side of the centre of the pupil. It is added if the angle is negative—*i.e.*, the light seen to the

outer side of the pupillary centre. This test is extremely convenient in hospital work, as well as for quick work in private practice ; it can be used in all cases, even in very young infants.

Neither of the above tests is scientifically accurate, but they are both useful and convenient for obtaining a preliminary idea of the case before us. They need no special instruments, and are therefore the most convenient

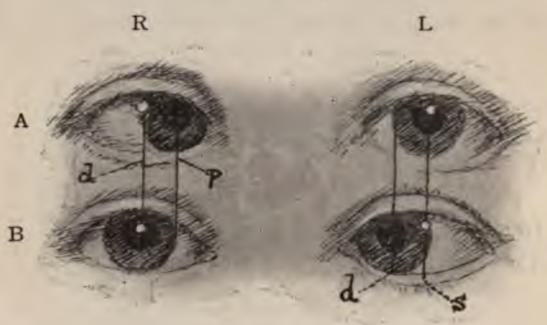


FIG. 12.—PRIMARY AND SECONDARY DEVIATION.

A, The right eye is squinting and is in a condition of primary deviation, *d, p* ; *B*, the right eye is straight, but now it is the left eye that is squinting—*i.e.*, the condition of secondary deviation, *d, s*. The parallel lines show that *d, s* exactly equals *d, p*, *i.e.*—the primary and secondary deviations are exactly equal. Compare points of light with Fig. 10.

methods for hospital practice. If it is desirable to investigate more elaborately one can do so with the deviometer, or by means of one of the following methods :

3. **Priestley Smith's Tape-Measure Test.**—The requisites are a dark room, a lamp, a retinoscopic or ophthalmoscopic mirror, and a double tape 2 metres long. One half of the tape is black, the other half coloured. The coloured part is divided into twelve parts, numbered in multiples of five, from five to sixty, and attached at its end is a small weight to keep it taut while in use. At the end of the black tape is a ring, and another is placed at the junction of the black and coloured portions of the tape. The following is the method of measurement : " The patient holds the end of the black tape against his face, directly

under the non-squinting eye, while the observer stands directly in front of him, with the ring attached at the other end of the tape over his thumb or the handle of his ophthalmoscope, which he holds in front of the eye. The patient looks directly into the ophthalmoscope, from which a light is reflected into the squinting eye. It will be noted that the image of the light from the ophthalmoscope will be to the outer side of the centre of the cornea in convergent squint, and to the inner side of the centre of the cornea in divergent squint. The observer now takes hold of the coloured tape at the ring, the edge of the hand being held towards the patient for him to look at, and lets the tape slide between his fingers, carrying it in a direction opposite to that in which the eye squints. Both eyes should follow the hand, and, when the squinting eye has turned sufficiently for the image of the light from the ophthalmoscope to occupy the centre of the cornea in that eye, stop the hand, and note the distance it has moved along the tape. The number on the tape indicates the degree or angle of the squint. This method has the great advantage that it can be used on very young children.

FIG. 13.—SMALL INSTRUMENT CALLED A STRABISOMETER, OCCASIONALLY USED FOR THE LINEAR MEASUREMENT OF SQUINT.

" To assist in understanding this method let R and L (Fig. 14) represent respectively the right and left eye. The right eye presents convergent squint. The surgeon places the tape (A–E) in position before the non-deviating eye, then throws light on to R, and sees the reflex eccentrically placed outward, which shows that this eye deviates inward. Then, holding the graduated part of the tape, he moves it outward (at the same time moving the mirror) until the reflex is in the middle of the pupil. The axis of the deviating eye R will have moved from S to E, through

the angle SOE. The axis of the non-deviating eye L will have moved through an equal angle EAT. The angular movement of L, as measured by the tape line, equals the angular deviation of R."

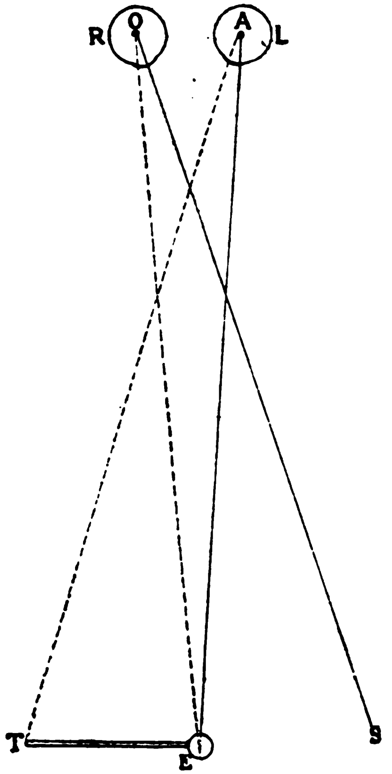


FIG. 14.—MEASUREMENT OF CONVERGENT SQUINT OF THE RIGHT EYE BY PRIESTLEY SMITH'S METHOD.

It will be noticed that every one of these tests is dependent on the tiny reflection of a light, or the image of a reflected light, upon the patient's cornea, the light or mirror reflecting the light being held in front by the observer.

4. **The Maddox Tangent Scale Test.**—This is an admirable device for measuring the deviation, but it is not easy to use for young children (Fig. 15). The figures are printed on strips of paper, which are pasted on two boards. The vertical board and larger figures are used in estimating cases of heterophoria (Chapters XV. and XVI.). The horizontal board only is used, the smaller figures of which represent tangents to degrees at a distance of 1 metre. In the centre of the scale is a candle. Below the candle is attached a bamboo rod, 1 metre long. The patient rests his cheek against the end of the rod. The surgeon puts his head below the rod, so that his eye is vertically below the rays of light which pass from the candle to the patient's face. The patient is first told to look at the light. The position of the image of the candle-flame on the cornea of

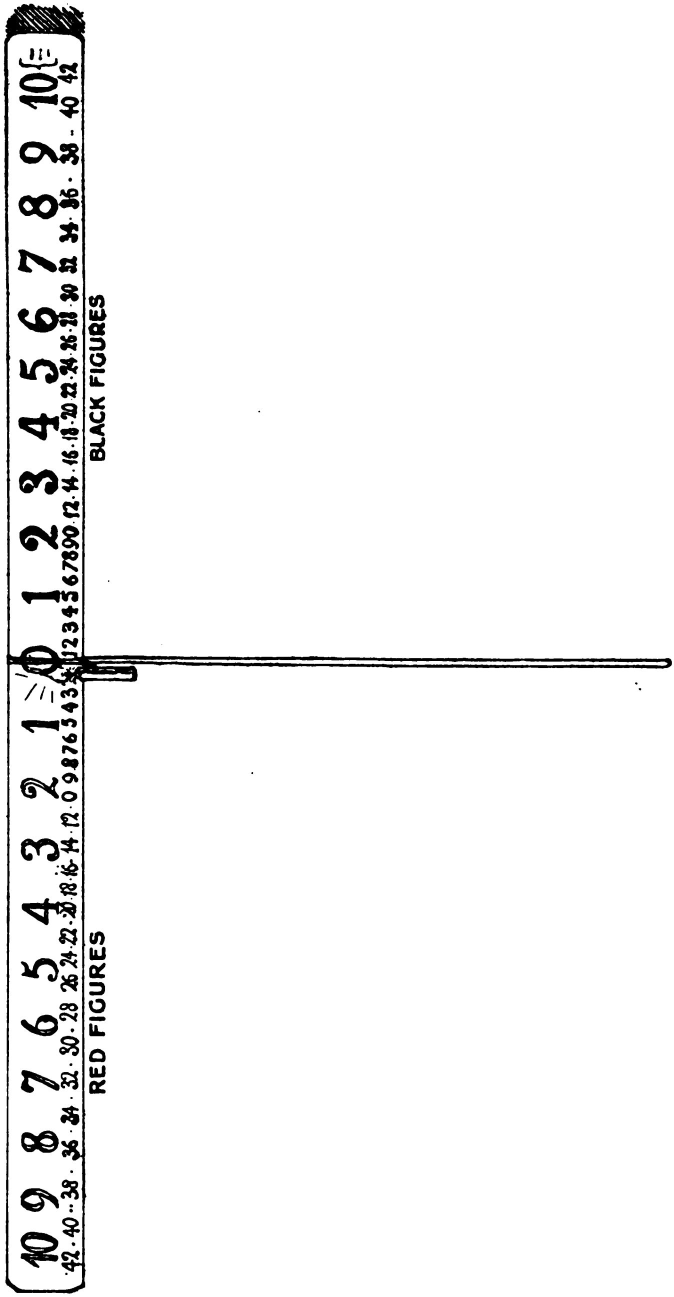


FIG. 15.—MADDOX TANGENT SCALE TEST.

The vertical board is not represented: it is used only for hyperphoria cases. The larger figures are for heterophoria, the smaller for measuring squint at 1 metre distance; the bamboo rod hangs down below the candle in the centre.

the fixing eye is noted. A guess is made as to the angle of the squint. The patient is now told to look at the figure which represents the guess. This might have been arrived at previously by the mirror test. If it is found to be too much or too little, other figures are named till the reflection of the candle-flame on the cornea of the squinting eye occupies a position exactly similar to that which it formerly occupied in the fixing eye.

5. **Measuring by Means of the Perimeter.** — Most oculists possess this instrument, and it may be thought a convenient way of measuring squint, but personally I do not like the method. The patient looks at a candle, or other bright object, in the distance so that his accommodation is relaxed. The face is resting on the chin-rest. The surgeon moves a small light along the arc of the perimeter until its image is opposite the centre of the pupil of the deviating eye. The degree of the perimeter is then read off, this giving the angle of the squint. The surgeon has to keep his eye above the taper, which is very awkward. This method takes no account of the angle gamma. It is impossible to use with very young children, and is, on the whole, not a very satisfactory method.

CHAPTER VII

THE NON-OPERATIVE TREATMENT OF CONVERGENT SQUINT

THE visual acuity, the angle of deviation, and other important factors concerning the case being known, the next thing in our examination is to determine the refraction of the two eyes, and decide upon glasses, should they be found necessary for any refractive error, and this procedure of itself forms an important part of the treatment of the squint. Both pupils must be dilated for this purpose by means of a mydriatic, which completely relaxes the accommodation. The best agent for this is atropine, either instilled in the form of the drops, or preferably, in younger children, in the form of the ointment (1 per cent.). This should be gently inserted, using for the ointment a clean, smooth, glass rod, placing it between the lids night and morning for a few days before the little patient's next visit. Should it be necessary to determine the refraction at once, drops are to be used, instilled every five minutes, several times; the pupils usually becoming dilated in about twenty minutes to half an hour, and sometimes much sooner. Retinoscopy is the quickest and easiest way to determine the refraction when there is complete cycloplegia.

In the dark room or recess for the ophthalmoscopic work it is a good plan with small children to get them to kneel on a cushioned chair. The chair is turned about, and the little one rests comfortably over the back, contented and happy, facing the surgeon, who invites him to fix the eye under examination on the retinoscopic mirror with some encouraging remark, such as "Look at the pretty thing I

have in my hand." Supposing a child will not look, the nurse, standing immediately behind the surgeon, attracts his attention by means of bright toys. With an infant the nurse is seated, holding it in her arms; the straight eye is first covered by bandaging it with a soft handkerchief, then lenses are one by one handed to the nurse for her to place in front of the eye examined, or she might have the box of lenses by her side and pick them up, each one in order as directed. Thus the retinoscopy is quickly and accurately worked out. Racks of lenses for retinoscopy—*i.e.*, small lenses fitted, one above the other, in frames of light wood—are made by Down Brothers, Borough, London; they are excellent, and may be held by quite young children who are intelligent enough to hold them as directed. Most of these instruments of foreign make are too large and heavy for children.

To try and place an ordinary trial-frame on the face of a small child is to attempt an impossibility, or, at least, it is creating for yourself unnecessary difficulties.

If in the squinting eye approximately good vision still exists, associated with hypermetropia, almost the full correction in young children may be prescribed, including that of any astigmatism present. The general rule recommended is to deduct about 0·5 degree from the spherical part of the retinoscopic finding.

The glasses must be worn constantly; on no pretence should the child ever be without them. It is important that the spectacles should fit accurately, and that their quality should be good.

The sooner orthoptic treatment is commenced the better; especially is this important when there is hope of obtaining full development of the fusion faculty.

It is a mistake to imagine that children under three are too young for glasses. Even infants may be greatly benefited with properly-fitting glasses, which in their case are tied on with tapes, these tapes going through loops at the extremities of the short side-pieces that reach up to the ears, but no further. These sides are so short that when the child's head is lying on the pillow they do not press or

cause any discomfort, but remain accurately adjusted to the face.

Thus the infant may be put to sleep in the daytime without their being removed. Prejudice against infants wearing glasses must be overcome: no child is too young to wear spectacles when they are necessary. Because of the infant's tender skin a little wool wrapped round the short side-pieces is advisable. Some authorities recommend a broad plate of tortoise-shell to be carefully fitted under the bridge-piece, so as to prevent rust and to distribute the pressure over a larger area; in any case, the bridge-piece must be broad, flat, strong, and accurately fitted. The glasses should be as close as possible to the eyes without touching the lashes. The frame should be made of the very best quality of steel. They ought not to irritate the skin, but if there is any tendency for them to do so, the application every night of a little vaseline will harden the skin and render it more able to tolerate the slight pressure caused by them.

There are certain things we must keep constantly in view in treating all cases of convergent squint. They are as follows: (1) The vision of the squinting eye must be prevented from deteriorating, and when neglect unfortunately has already resulted in amblyopia, the sight of the eye has to be restored as soon as and as much as possible; (2) to try and remove the fundamental cause of the squint by fusion-training at the very earliest possible age; (3) to rectify the deviation by restoring the visual axes to their normal relative direction.

A good prescription for glasses is of the utmost importance, but, as regards the squint, this cannot be exclusively relied on. A child will continue to squint behind his glasses, in the majority of cases, especially while reading, and a prescription for convex glasses is frequently deceptive. A cure of convergent squint by glasses alone is of extreme rarity, even although they are prescribed from the beginning of the trouble. A case is not really cured so long as the deviation returns on removal of the glasses.

Years ago the French oculists prescribed frequently

what was termed a *louchette.* This consisted of a disc or shell before the squinting eye, with a hole in the centre, and another opaque disc or shell for the fixing eye, the two being tied on with tapes or mounted in a frame. The so-called "good" eye was occluded, and the squinting eye compelled to constantly exercise fixation. It was suggested by Javal that a lens correcting the refraction of the squinting eye should be inserted in the hole of the *louchette.* This treatment seems to have fallen into desuetude, possibly because parents disliked seeing their children wearing such unsightly things; but a modification may prove useful in some cases, where the vision of the squinting eye needs exercising. By simply gumming black paper over one spectacle lens of the child's glasses, or fastening a fold of paper round it, the squinting eye may be forced into exertion and its vision greatly improved, the paper being easily removed at any time. This device acts just as well as a *louchette.*

Some authorities have recommended covering for a short time daily the fixing eye, but it is unsatisfactory, because experience shows that it is hardly ever carried out, except in a dilatory manner. Continuous occlusion of the so-called good eye is by far the better plan, except in slight cases, when atropization of the fixing eye is sufficient. With intelligent children the cultivation of a habit about to be described is recommended. As regards the use of atropine, the eye is kept by this agent practically occluded for near vision, the accommodation being paralysed. The eye to be exercised is (by occlusion or by the atropization of its fellow) forced to accommodate for near vision, and in doing so has to converge in a normal manner. Thus the habit of excessive convergence is broken.

When there exists unequal refraction of the two eyes (anisometropia), glasses slightly under the full correction of them both should be ordered, except when an eye is myopic, then the exact correction of the myopic one should be prescribed. A certain number of convergent squint cases are myopic. It is a mistake to under-correct these; they should be given their full correction, and wear their glasses

constantly. Also astigmatism should always be exactly corrected, great care being taken to have the axis perfect. The atropine, applied for the retinoscopy, may advantageously be continued for a few days until the glasses arrive from the optician's, but there is danger in continuing atropization of both eyes for too long a time. Surgeons have been in the habit of ordering atropine to be applied to both eyes for weeks or months at a time; this has been done with the object of straightening the eyes by means of prolonged paralysis of the accommodation, but it has been disastrous, since the very worst cases of amblyopia ex anopsia have been those that have been treated in this way. The text-books have been greatly at fault in recommending this harmful procedure. The squinting eye is frequently astigmatic; it is sometimes the more ametropic of the two, and to subject such an eye to prolonged atropization is an absolutely certain way of keeping it from being used. Right views concerning amblyopia would have kept surgeons from such disastrous practice. Cases that have been subjected to this treatment have the worst prognosis so far as the non-operative management of their squint is concerned. The spectacles should be prescribed for constant wear, and the parents should be given to clearly understand that this means they should never be removed, except for bed at night and for toilet purposes. Children break their glasses frequently, but it is the rarest thing in the world for any injury to their eyes to accrue as the direct result of this accident, because the lenses crack across, and chip only at the sides, where the frames prevent any splinters; the eyelids also, tightly closing in a reflex manner, efficiently safeguard the eyeball in the moment of danger. The best shape for young children is the round form of lens. If there is a cylinder the axis must be secured accurately in its place by means of Canada balsam when the optician is fastening the lens into its frame. Should the glass break and need replacing this can be easily melted.

Some cases are found to have equally good vision in each eye, although the vision is not binocular, and the fusion faculty is lacking. These are mostly cases of alternating

squint, and they have what we may term alternating vision. At one moment the vision of the right eye is being used and that of the left neglected, then the neglected eye is squinting, and presently the child, for some unaccountable reason, changes the suppression of vision (and along with it, of course, the squinting) to the right eye, and the left fixes and sees perfectly. This alternate suppression of the vision first of one eye and then of the other, together with the absence of any binocular vision, is immediately demonstrated by the diploscope, the child at one moment seeing only the first and third of the four letters, while only using the right eye, and at another moment seeing only the second and fourth letters, while only using the left eye.

Unilateral convergent squint cases are always on the high road to become amblyopic in the eye that habitually squints. It is imperative that measures should at once be taken to overcome the suppression of the vision that belongs to the neglected eye, and this is done by occlusion or atropization of the other. Besides wearing a *louchette,* or the modification of it mentioned, continuous occlusion of the so-called " good " (*i.e.,* fixing) eye may be effectually practised by bandaging, or by a small gauze pad, fixed on with plaster. Soap plaster does not hurt the child's tender skin in the same way that strapping does, and should therefore be preferred. It is important that the child be upset as little as possible. In the case of an infant a small pad and light bandage should be applied to the eye that does not squint.

The surgeon should endeavour always to maintain friendly terms with his little patient. If the eye has to be occluded by a pad or bandage, perhaps it is better that some other person should do this, and that the child should not remember it is a grievance against the doctor. The nurse or mother might easily be shown how to apply this, while the child was out of the room. It is best to always give written directions, and impress upon the mother the reason for occluding the " good " eye. " To compel the bad eye to work !" is an explanation that most parents are intelligent enough to grasp. To talk learnedly to the laity about

amblyopia and suppressed vision is absurd. More detailed pathology than the above simple explanation could not be understood.

Supposing the vision of the squinting eye is beginning to become amblyopic, but there remains still more than $\frac{6}{36}$ of vision, it is not necessary to bandage the eye, only that atropine should be ordered for the fixing eye, or the spectacle lens, belonging to the fixing eye, covered with black paper. Care should be taken, if atropine is used, that none of it comes near to the squinting eye. Here it is well to explain to the mother that the child's vision in the eye that is atropized is not affected for distance, and that the application is merely for the purpose of giving accommodative rest —*i.e.*, rest as regards near vision, that one eye should be resting while the other is working. The child may be given some coloured beads to thread, be encouraged to play with small toys, look at picture-books, etc.—all this so as to exercise the eye that in the past has squinted because its vision has been neglected.

If the eye is covered over, it is important that the child should not be worried by injudicious severity in this measure. Squinting children are generally nervous children, and a compromise sometimes has to be effected so as to make the burden come easier. The bandage may be placed on the eye, or the *louchette* worn, at special times when the child greatly desires to see—a visit to the pantomime, on conditions that the non-squinting eye is covered, fireworks in the back garden, viewed only by the offending eye, pet animals, birds, and favourite toys, sweets, etc., placed about the room for the child to fetch while the "good" eye is covered, etc. Meal-times are recommended as affording a favourable opportunity for the straight eye to be covered over.

An excellent suggestion of Javal's is that of teaching the child to shut the "good" eye without putting up his hand to the eye to do so, simply by the unaided face muscles on that side, chiefly the orbicularis palpebrarum, while keeping the other eye open. It is an interesting fact, which I have not found recorded in any of the text-books, or

noticed by any authority on squint except Javal, that the stronger eye in strabismus cases seems to have the weaker orbicularis palpebrarum muscle. I have constantly observed this to be the case. The fixing eye cannot be shut independently by its own lid-muscles. This is especially marked when amblyopia has supervened in the other eye, which can easily be closed by the lid muscles of that side, in striking contrast to the other. Squint cases that have been operated on, without subsequent exercises, show this peculiarity. The child puts up his hand to close his strong eye, otherwise he would close both ; the weak and squinting eye can be closed by the facial muscles without needing the hand. Javal suggests that the child should be taught by patient, persistent, and methodical practice to overcome this defect. It is a matter of practice, just as teaching a child to become ambidextrous is, but it becomes an impossibility when amblyopia is established in the neglected eye. The parents, nurse, or governess should assiduously train the child every day by the following procedure : Open the "worse" eye very widely, while holding the other closed by means of two fingers, which hold the lashes of the upper eyelid down upon the cheek. Little by little, raising the fingers, one becomes able to open and to shut by will-power the "good" eye independently of the other. Like much else, it can be made a matter of play to the child. Children are born mimics, and if the mother takes the trouble to show the child how to do it he will soon learn. By first closing one eye and then the other, the little one will try to imitate, and if not successful, the above procedure with the fingers to the lashes may be taught. The child will enjoy the fun, and the mother must see that the "good" eye is the one more frequently closed. Atropine in the "good" eye may make the exercise easier, the mother being careful that it is the lid muscle of the eye which has the dilated pupil that requires to be exercised. With regard to these exercises Javal writes : "I ask my patient to take an active part by imposing tasks that he will accomplish more or less rapidly according as he puts more or less patience, capability, and intelligence into them." The great French oculist was

undoubtedly right in expecting an intelligent child to help in the cure of his own squint, and the juvenile propensity to imitate others may be made of some service in this connexion. Javal continues : " In all bodily exercises success is obtained by proceedings altogether different according to the aptitude, and especially according to the age of the patients. Put a child on skates or on a bicycle and leave him to it : he will succeed more quickly than an adult, even although the latter be furnished with directions how to do the thing stated theoretically in the most precise manner." In cases where a spurious visual axis (eccentric fixation) has already unfortunately become established the training is excessively difficult. A child being coaxed to read with the defective eye or to thread beads (the other being occluded or atropized) will turn the head and eye to one side so as to employ the false macula, this jury-mast sort of macula being more convenient than the true one for the diverted axis. When there is commencing amblyopia both the light sense and the form sense are becoming impaired. Sheep cannot be distinguished in the distance from cows, except by the colour, although the guess may be made because the child has observed that they huddle themselves more together. A strong desire for accurate definition becomes wanting. E. Browne lays special stress upon the use of the blackboard. It should be put up in the nursery or schoolroom, taking care to place it where there is no cross light upon it. With the sound eye covered, while the other is exercised, the blackboard can be used in many ways. Letters may be taught on it, dots and lines counted, drawings shown of familiar objects, etc. Pictures, old posters, and diagrams may all be exhibited to the child while the straight eye is covered. The child should be encouraged to use the chalk himself at the blackboard. Later on, when the child is old enough, simple forms of bimanual drawing, with both eyes, of course, uncovered, is excellent practice. Children of school age that squint need not have their education delayed, but it should be modified. It is a pity that the slate and school-book are not abolished, as they can do nothing that the blackboard cannot do better, and so far

as children's eyes are concerned, the latter is infinitely to be preferred. For the child to use the chalk himself at the blackboard is the best way of exercising the visual perception, especially in the older children, who are able to do

FIG. 16.—AMBIDEXTROUS DRAWING.

in this way bimanual drawing. The child stands in front of the board with two white chalks, one in each hand, and, using both hands at the same time, copies floral designs, vases, etc. (Fig. 16).

Dr. Emil Javal recommends the use of his ophthalmo-

meter in working out the refraction, but this is unnecessary, and is, besides, an extremely difficult instrument to use with nervous, restless children. It needs such accurate adjustment and such perfect fixation of the eye that is being examined.

The child should on no account ever be without his suitable and properly fitting glasses, which relieve the excessive effort of accommodation in the straight eye when the latter is uncovered, and put the squinting eye in the most favourable circumstances possible for clearness of vision.

Although we may fearlessly in young children prescribe almost the full correction, as I have already remarked, yet this is not the case with older children in hypermetropia and hypermetropic astigmatism. It is impossible to lay down any hard-and-fast rule, because even the astigmatism may be latent owing to the condition and habit of the ciliary muscle. Professor Browne has compared it to "the goose that is accustomed to bow her head while passing under a five-barred gate, performing the same movement when entering a lofty doorway." One has to feel one's way when habit has become established like this. For instance, in a boy of ten or twelve years of age, say with oblique astigmatism of + 1 D in both eyes, and the lowest meridian in both + 4·5 D in the better eye and + 5 D in the squinting eye, unable to take a weak cylinder for either eye when the mydriasis has passed off, the astigmatism being latent, the surgeon had better commence with about + 2·5 sphericals for both sides, and wait for a future occasion to deal with the astigmatism. It is lamentable that there has been, and, I fear, still exists, a great amount of ignorance on the subject of squint, not only with the laity, but, unfortunately, even with the professional attendant, who advises delay, and tells the parents that the child will "grow out of the squint." He could not make a more unfortunate mistake. Delay is dangerous, and the treatment ought immediately to be begun as soon as the first "glide in the eye" is noticed. No patient is too young to commence treatment for his squint. Squint is something

that can be seen, and as soon as it is seen it should at once be treated. The crass ignorance concerning squint by those who should know better is well illustrated by a story told by Professor Browne. He writes : " A boy was brought to me as an infant with a severe squint, showing very infrequent remissions. By a careful measurement of the refraction, and the constant use of glasses, the squint disappeared, and was only apparent as an ordinary periodic squint when the glasses were removed. At first great gratification at the result was expressed, but after a time the aunts, who adored the child, discovered that they could not see through the glasses, and that they were strong enough for an aged person. Evidently something was wrong, and a practitioner was consulted for an " independent opinion." He laid it down that an operation was necessary, and, if not performed, one eye would go blind. Now, it has been known for a considerable number of years that operation has no effect on the vision, especially in eyes that have been trained from an early period with a fully-corrected refraction. The credulity of patients need not excite our wonder . . . but in the profession there should be a standard more stable than feminine emotions. . . . The operation was entirely superfluous, and may yet be repented." The repentance, of course, would come to the patient's friends in after-years ; the surgeon who performed the unnecessary operation might be dead and buried, but a heritage of blame would be handed down for the profession generally to bear the brunt of. This is just the kind of case that would probably end in a marked divergent squint.

Mr. Browne has contrived a spectacle-frame which appears to me more useful than sightly. It has the Manx-like peculiarity of having three legs, two in the usual place, and one rising from the middle of the bridge, all made of copper, so as to be flexible. They are covered with ribbon and tie at the occiput, so that the dragging the ears and the marking of the nose common with the usual pattern are avoided.

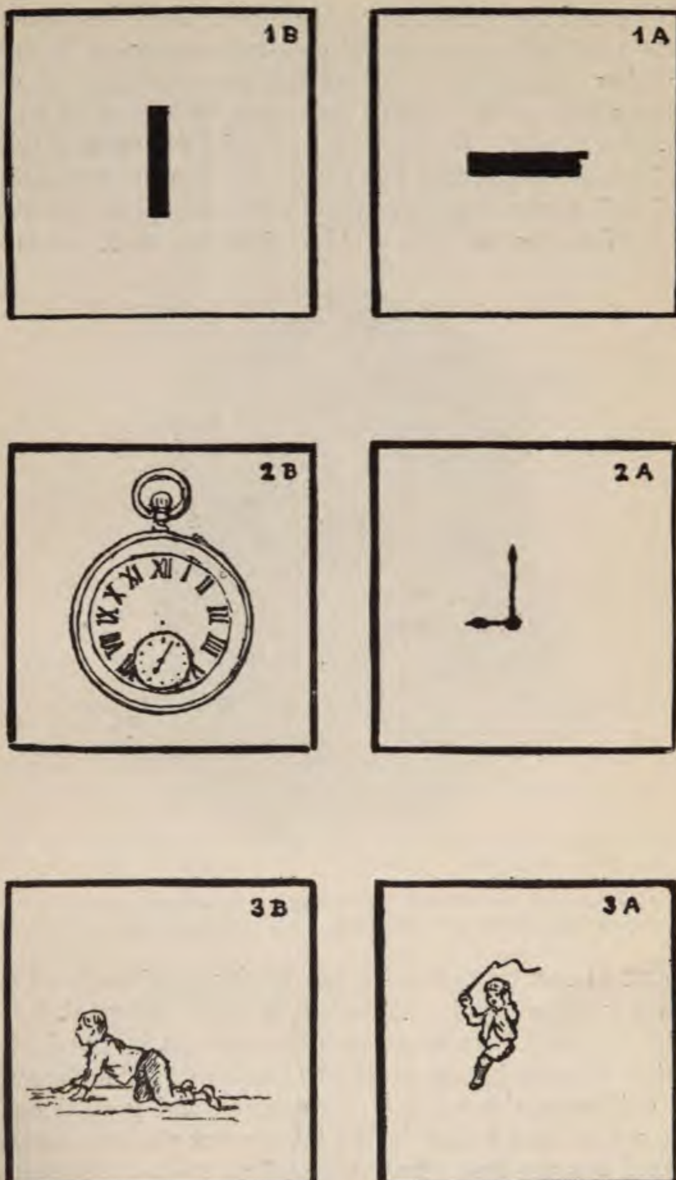
The two principal instruments to be used in the encouragement and development of binocular vision, which frequently forms a difficult feature in the treatment, are the diploscope

of Rémy and the amblyoscope of Worth. Both instruments can be used with quite young children, especially Worth's, which has the advantage of forcing the objects to be seen on the vision of the child's two eyes by means of bright transmitted light. It can be used on the youngest children —indeed, as soon as they can talk. The diploscope could be fitted with cards which have small pictures in place of letters, but it is better for rather older children, as it needs an

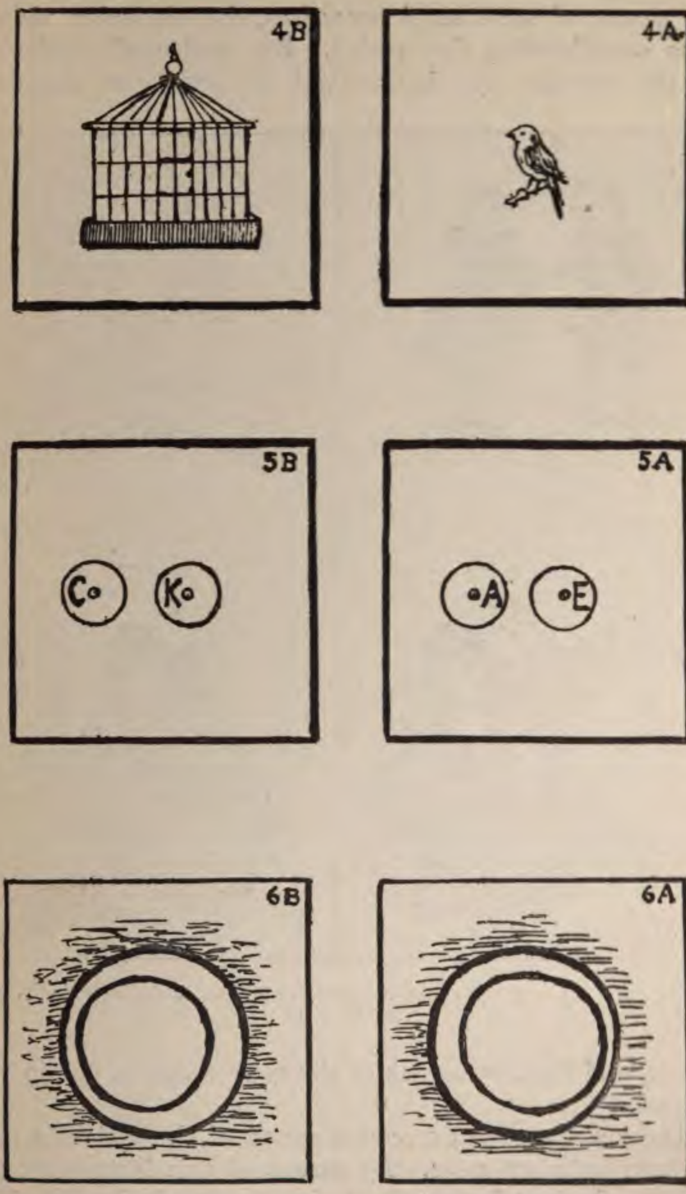
FIG. 17.—EDGAR BROWNE'S THREE-LEGGED SPECTACLE FRAME TO PREVENT DRAGGING AT THE EARS AND MARKING OF THE NOSE.

amount of mental concentration hardly possible to obtain from a younger child. Indeed, it is upon the mental concentration that it enforces that the success of the instrument in overcoming suppression of an eye's vision depends. The child sometimes has to be spurred and goaded on so as to see all four letters in the instrument simultaneously.

Javal was the first who attempted to bring the squinting eye into such a condition of vision that diplopia began to be experienced, and then he endeavoured to bring back,



FIGS. 18, 19, 20, A AND B.—SPECIMENS OF DEVICES FOR WORTH'S AMBLYOSCOPE.



FIGS. 21, 22, 23, A AND B.—SPECIMENS OF DEVICES FOR WORTH'S AMBLYOSCOPE.

by means of stereoscopic exercises, the binocular vision, thus straightening the squint. By prolonged occlusion of the straight eye he thought to arrive at the first

FIGS. 24, 25.—STEREOSCOPIC PICTURES FOR CHILDREN (AFTER E. HEGG).

result, and then by means of the stereoscope to obtain the second.

The amblyoscope overcomes much of the difficulty met with in ordinary cases. By means of this instrument we at once detect whether the fusion faculty is developed or not.

The description Mr. Worth gives of his instrument is as follows:

"It consists of two halves, joined together by a hinge. Each half consists of a very short brass tube joined to a longer tube at an angle of 120 degrees. At the angle of the junction of the tubes is an extremely thin oval mirror, protected on the outside by an oval plate of brass. Each

FIG. 26.—LITTLE GIRL EXERCISING WITH THE AMBLYOSCOPE.

half of the instrument has at its distal end an object slide-carrier, and at its proximal end a convex lens having a focal length of 5 inches—the distance of the reflected image of the object slide. In front of each lens is a slot, into which a prism, axis vertical, may be inserted if required. The diameter of the tubes is 1½ inches. A brass arc connects the two parts of the instrument, being clamped on one side by a binding screw set in a long slot, and on the other by a

binding screw set in a short slot.* When the screw in the long slot is loosened, the two parts of the instrument can be brought together to suit a convergence of the visual axes up to 60 degrees, or separated to suit a divergence as much as 30 degrees. When this screw is tightened and the screw in the short slot loosened, an amplitude of movement of about 10 degrees only is permitted."

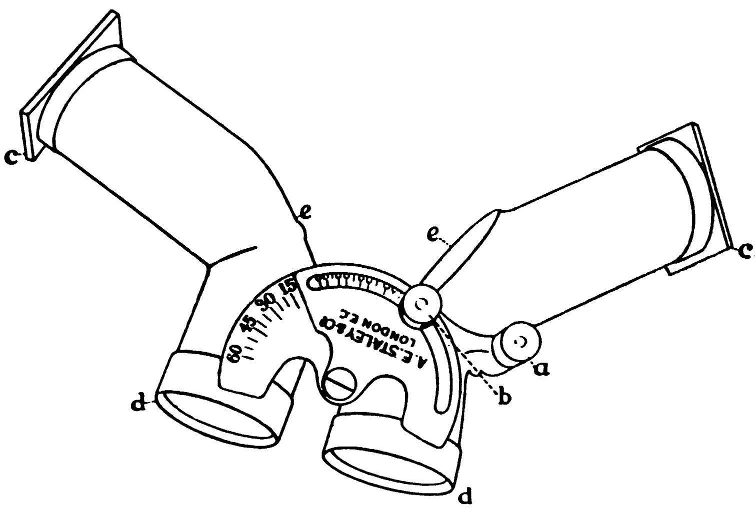


FIG. 27.—IMPROVED PATTERN OF WORTH'S AMBLYOSCOPE.

a, Vertical screw adjustment; *b*, single binding screw to regulate the horizontal movements; *cc*, carriers for the two object slides; *dd*, slots for prisms in front of the lenses; *ee*, posterior surfaces of mirrors inside instrument. The brass arc of the old pattern with its two binding screws is replaced by two horizontal plates, the upper moving over the lower one. In the above diagram the upper plate has the maker's name on it, the lower plate being marked in degrees.

The instrument can be illuminated either by specially arranged electric lights or by lamps placed in position on a table. Dr. Maitland Ramsay has substituted total reflecting prismsf or the mirrors (*Ophthalmoscope*, vol. iii.). He has also devised a very perfect lighting apparatus by which the illumination is varied and regulated, and Dr. N. M. Black has added a vertical screw adjustment,

* Some of the instruments have only a single slot, the long one.

by means of which one tube can be moved above or below the plane of the other in order more readily to adapt the instrument to cases of squint in which there is a vertical deviation. "This improvement has the advantage that one may, in a case of obstinate suppression, call attention to the second image by temporarily throwing it above or below the plane of the other."

With regard to the devices used in the instrument for fusion-training they are of three kinds :

"1. Those which only require simultaneous vision of objects that are unlike each other, such as a cage and a bird. One object is on the one slide and the other on the other ; the two are placed in the amblyoscope and made to come together. When the child is able to see the bird in the cage there is the first grade of binocular vision—*i.e.*, simultaneous macular perception. A great many devices can be arranged : the simpler they are the better—a clock face and hands, a clown and a hoop, a mouse and a trap, etc.

"2. The second class of devices need some amount of fusion, a stage further than simultaneous macular perception. Imperfect objects like each other have to be fused together so as to form a perfect picture. Examples of this kind are two men—one without a leg, but holding an umbrella ; the other has the missing leg, but no hat nor umbrella : the two are fused together, and form the complete picture. The child that blends the picture sees the whole man, with leg, hat, and umbrella complete.

"3. The third set of pictures are for the purpose of developing the sense of perspective. They correspond to the most advanced grade of binocular vision."

Small designs of this character could easily be drawn by the surgeon, or by anybody, ready for the little patient's next visit ; they can be easily done by means of two tracings so as to correspond, a part of each one being omitted according to what is wanted. Paste the papers on two squares of glass, about 1½ inches square, using, of course, thin translucent paper. It is extremely important that the education of the fusion sense be undertaken at the earliest possible age. Indeed, this is the only key to success. The deviating

eye must not be too blind; the child should see with it a white ball, 1 inch in diameter, at 6 yards.

My friend Mr. Brookbank James, of the Westminster Hospital, has recently devised an instrument something similar to the hinge stereoscope of Javal. It is a simple arrangement of two mirrors at a movable angle, the cards being reflected in the mirrors. The pictures are suitable for young children—for instance, the "Jack" cards are

FIG. 28.—BOY EXERCISING WITH HOLMES' STEREOSCOPE.

together the representation of a sailor's body, the upper half on the one card and the lower half on the other. Four letters, which the child can only spell when the two halves come together, give the sailor's name, "Jack." This instrument can be folded up; it takes up very little room, and can be carried with the cards in the surgeon's bag or pocket. It needs no special light—ordinary daylight is sufficient—and may be used for some cases with a large number of various cards instead of the amblyoscope, or it may occasion-

ally be resorted to as an additional means of keeping up the child's interest. Children like variety. Besides, this instrument, not needing such bright illumination, will test the child's powers of vision with both eyes. It is lighter to hold than the amblyoscope. There are numerous other good patterns of stereoscopes. There is Wheatstone's (the inventor's) original instrument; also there are Javal's, Parinaud's, Holmes', Landolt's, Priestley Smith's, Brewster's, etc. Worth's and James's instruments are both really varieties of stereoscopes, but they are attempts to overcome the difficulties that are encountered in ordinary stereoscopic exercising of the two eyes. I think Worth's amblyoscope is a most successful invention. He aims at creating a desire for binocular vision at the time when the faculty of fusion is possible to be developed. Numerous cards are published which suit most of these stereoscopes. Some of the devices are geometrical figures, letters, etc.; others are in bright colours of pictures to interest children (Figs. 24 and 25). There are those of Javal, Kroll, Emil Hegg, and Wells's selection of these charts (published by Meyrowitz, New York). The great disadvantage of a simple stereoscope in strabismus cases is that the surgeon cannot vary the prismatic element to suit the individual case. It is in this that we have the great advantage of Worth's instrument. The phoro-optometer, with Dr. Wells's stereoscopic attachment, also meets the requirements of most strabismus cases. When there is good vision in both eyes—that is, suppression of one eye's vision has not yet taken place to any marked degree—Brookbank James's simple instrument is a good one to work with, and may be prescribed for home use. For home use explicit instructions should always be given. In established cases of squint the vision of one eye soon becomes the only vision that is used, the other being suppressed. Under certain circumstances he sees only with the deviating eye, but the fixing eye is the one usually that sees. The two eyes are not used simultaneously.

The first step in the treatment is to overcome this habit of suppression. The patient wears the spectacles which

correct his refractive error. Should there be any vertical deviation, as shown by the mirror test, prisms, axes vertical, which correct this are placed in the slots of the amblyoscope.

"The child, on the surgeon's knee, is facing the lighting apparatus, and the amblyoscope is roughly adapted to the angle of his squint. A pair of object slides which require no fusion are first put in the instrument. These are to elicit simultaneous perception. Each of the two lights is 3 or 4 feet away from its object slide. For instance, suppose we have the cage and the bird, the cage before the fixing and the bird before the squinting eye. The child on looking into the amblyoscope will see only the cage. The little patient is now told to look for the bird, while the light is brought nearer and nearer before the deviating eye. The illumination of the object slide before the deviating eye at last becomes so intense that the vision of this eye can no longer be suppressed. The child suddenly says he sees the bird he was told to look for. He has now lost the cage, and the light belonging to that object slide has to be brought nearer. By thus readjusting the relative distance of the two lights, after a few minutes' alternation of the vision of the two eyes, simultaneous vision of both cage and bird is obtained. Then the child is permitted to grasp the amblyoscope with both his hands, and the surgeon, placing his hands over them, converges and diverges the two halves of the instrument, so as to cause the bird to appear to go in and out of the cage. Other similar pairs of object slides are then shown. The child soon learns to move the instrument himself so as to put the bird in the cage, the cat on the chair, the clown in the hoop, etc."

The above is almost verbatim Worth's own description of the use of his instrument, and it is in this way I myself invariably commence with its use. One has to carry on a running conversation all the time with the little patient, as it is only by encouraging his prattle we learn whether he sees r not. We have now reached the stage where those slides equiring fusion of images may be shown. The child, for nstance, at first sees two men, each picture being imperfect.

"The movement between the two halves of the instrument is restricted to about 10 degrees. Other pairs of slides requiring fusion of images are successively shown, and the child encouraged by one's remarks to examine every part of the fused picture. After a time the angle of convergence of the instrument may be increased slightly without the fused picture coming to pieces. The child has now, under these special conditions of illumination and convergence, the second grade of binocular vision—*i.e.*, true fusion with some degree of amplitude.

"Our next step consists in increasing this amplitude of fusion. . . . An attempt is made to gradually diverge and converge the two halves of the instrument more and more while the child is examining and talking about the various pictures shown him. After some practice in the case of a young child, a considerable range of movement becomes possible, fusion being still maintained. This 'amplitude of fusion' may, for practical purposes, be taken as a measure of the extent to which the fusion faculty has been developed.

"A child who has any considerable amplitude of fusion will nearly always be found to have acquired the third grade of binocular vision also—the sense of perspective. . . ." The next step is to gradually equalize the light before the two eyes. This may readily be done at this stage without a return of the suppression. If a child be young enough a very powerful "desire for fusion" may usually be created in about six lessons, given at intervals of one week.

It is unwise to allow any of this training with Worth's instrument to be carried on at home. It must be done by the surgeon himself; the mother or nurse could not be trusted to do it properly.

The "desire for fusion" brings about a sudden cure of the squint when that desire has been firmly established, although in some delicate children an occasional squint may still be noticed when the accommodation is relaxed. It is in these cases that subsequent stereoscopic training comes in useful. When once the fusion faculty has been acquired it will not be lost, and if the squint has been com-

pletely cured in this way it prevents a deviation ever occurring again. When once a cure has resulted, nothing but ocular paralysis could cause the eyes to deviate.

When unable to overcome the suppression by Worth's method, as above described, I have sometimes succeeded in doing so with the diploscope. This instrument is much more tedious for the child. After about half an hour looking through the instrument the child suddenly cries out that he sees all four letters. These patients have to work away at the diploscope under superintendence, to see that they

FIG. 29.—"LECTURE CONTRÔLÉE," OR JAVAL'S METHOD OF "BAR-READING."

concentrate, while the surgeon goes on seeing other patients. When the suppression is overcome in this way more than half the battle is won.

Finally, when the faculty of fusion is well developed, and binocular vision fully established, should there remain any tendency to deviation, it is a good plan to advise bar-reading at home for so many hours a day, using some such device as that of Javal (Fig. 29), providing the child is old enough to read in this way. Several good London opticians supply a bar-reading arrangement. E. Browne's "Squint Reader" is a useful instrument for these bar-reading exercises. With poor patients even the exercising by means of a book and a pencil held vertically before it is sometimes found sufficiently efficacious.

CHAPTER VIII

DIVERGENT SQUINT: THE MYOPIC AND OTHER VARIETIES

THE axis of the deviating eye is directed outwards—external strabismus.

Up to recent years the general view concerning divergent squint has been that it was due to some feebleness (insufficiency) of one or both internal recti muscles—that a congenital weakness of one or both muscles prevented convergence from properly taking place, or, at least, prevented it from being sustained. There are two things that militate against this view: one is, that divergent squint is scarcely ever seen in young children, occurring nearly always, at the outset, in adolescence or in older children who have been for some years myopic, thus putting completely out of court the idea of congenital feebleness; the other thing is that it is unphysiological to suppose that a muscle continues too weak for the very object obviously in view in its having been fashioned as a muscle at all. Muscles invariably lengthen and thicken according as there is a demand made upon them. This is a universally acknowledged fact in physiology, and it is in myopic cases, where we have a demand for convergence together with an effort of accommodation, that divergent squint frequently and ultimately occurs.

Parinaud states that it is not insufficiency of any muscle or muscles, but rather a feebleness of the innervation of convergence; in other words, we have, to start with, plenty of muscle power, but there is not a sufficiency of nerve power to meet the demand that is made for convergence.

There are two clearly-defined varieties of this insufficiency of convergence, which result in divergent squint, although it is not always easy to distinguish the two forms in every case that comes before us. These two varieties or types are as follows :

1. Those cases due to myopia and other refractive errors.
2. Neuropathic cases.

1. In the myopic variety the lack of convergence develops gradually. It is intimately connected with the myopia, which generally has the form of compound myopic astigmatism in one or in both eyes. The weakness commences in childhood, and, as years go by, becomes more and more pronounced. It is described as constituting, at the first, a latent divergent strabismus. The desire for binocular vision is never strong. As above stated, it is not a question of any muscle weakness, but " a modification, either congenital or acquired, of the innervation of the muscles for convergence." There is not enough nerve power to meet the call on the internal recti muscles in convergence, and the child suffers discomfort when engaged in near work. Convergence is rendered more disagreeable from the increasing size of the eyeball, and the subject finds that by closing one eye he is able to read with comfort. Then gradually he falls into the habit of using one eye only, instead of the two, binocular vision being thus neglected ; the eye that is not used rolls outward. It is very rare for the divergence to be slight in amount, many of these myopic cases displaying an extreme divergent squint. This divergence is at first occasional and limited to near vision, the eyes again straightening when in repose—that is, when the child looks up from his work ; but later on the squint becomes fixed and constant for both far and near. Sometimes these divergent squints are alternating ; this is due to the fact that there exists a certain amount of weak binocular vision, the patient using one or other eye indifferently, and because he has habitually covered, for near work, the right eye at one time and the left at another time, the refraction of

the two eyes being equal. Later on circumstances may cause the squint to become unilateral, or the case may continue to remain as one of alternating divergent strabismus. Although myopia and myopic astigmatism are by far the commonest forms of refractive error, it is not in every case of divergent squint that we find this association. Some cases are emmetropic, and others are even hypermetropic, as, in like manner, we have seen that some cases of convergent squint are found to be associated with myopia.

According to the statistics of Donders, about 60 per cent. of cases of divergent squint are myopic. One should take into account the poor use myopes make of their accommodation, which fact partly explains the frequency of myopia with these cases of divergent squint, for, resulting from the neglect of this function, we have a relaxation of the associated synergy of both accommodation and convergence. There is a loss of the balance of power between accommodation and convergence, which results in convergent or divergent squint, according to accompanying circumstances.

Donders gives, as the chief reason for divergent squint in myopes, physical conditions created by the myopia, the chief cause (according to this authority) being the distension and change in shape of the eyeball. This elongation of the globe, in conjunction with a slight displacement forwards of its centre of rotation, reduces its mobility in all directions; but while the diminution of the extent of outward movement has no other effect than that of restraining lateral excursions, restriction of movement inwards brings about much more serious results, owing to the obstacles it opposes to convergence. This mechanical difficulty is still further increased by a diminution of the angle gamma. This is always low in myopic eyes, and it may even be negative, and it necessitates for fixation at any given distance a much greater movement inwards for a myopic eye than for an emmetropic or hypermetropic eye. The inconvenience of this difficulty of convergence is increased by the fact that the myope, obliged to look at things very near, needs all the more to converge. It is the error of refraction itself, as well as the abnormal shape of the globe, that hinders con-

vergence in myopia. As the punctum remotum (far point) approaches nearer and nearer, the difficulty of convergence becomes greater and greater, until at last binocular vision becomes an impossibility.

Myopic divergent squint first makes its appearance, as a rule, when the patient is about ten or eleven years of age. Usually the child has been known to have been short-sighted for some years, being allowed by the school-teacher to occupy the front seat in the schoolroom, so as to see clearly the blackboard. It is quite in exceptional cases that the divergence is alternating; it is nearly always unilateral. The myopia is about 5 or 6 diopters when the squint develops. Usually the fusion faculty is good, but it is sometimes weak, and may even be altogether absent. Quite at the commencement there is no actual divergence noticeable, only a failure to converge, so that one eye only is engaged in near vision. Thus the function of convergence becomes more and more weakened from not being used, and one or other eye is seen to diverge, either because the patient falls into the habit of constantly neglecting this eye in near vision, or, finding the eye troublesome to him, he habitually screens it. If the fusion faculty has been perfect up to this time, there has been a tendency for diplopia to worry the patient, but now the eye diverging it is no longer used, and diplopia ceases. After a time the eye remains widely divergent even in distant vision. Because of the myopia, the very faint eccentrically placed image in the squinting eye causes no tendency to fusion. The divergent eye at first has the power to recover itself, then the images are more centrally placed, the desire to blend them causing the eyes in distant vision to be quite straight. This explains why, in a case of myopic divergent squint, the eyes are sometimes straight, sometimes widely divergent, and scarcely ever divergent to a slight degree.

Some authorities abroad have given as much as 29 per cent. of divergent squint cases associated with hypermetropia. This error of refraction is rarely met with along with divergent strabismus in this country or in America,

judging from literature on the subject—that is, if we exclude the cases which commenced as convergent squint.

How are divergent squint cases with hypermetropia to be explained ? The explanation of Donders was that certain hypermetropes sacrifice clearness of vision for largeness of retinal images while looking at near objects, a desire for large retinal images causing them habitually to hold objects close to their eyes, just as is the case with myopes, and so the same condition of things as with them come about. There is a demand for convergence impossible to meet, so that one of the eyes takes upon itself entire fixation, while the other rolls out, as in the divergent squint due to myopia. It is rare, however, to find young hypermetropes failing to use their accommodation strongly, and thus maintaining, while looking at near objects, their convergence, so that Donders' explanation is hardly a satisfactory one.

A set of conditions has, no doubt, existed which has diminished the tendency to fusion of retinal images ; thus there is a relaxation of the synergy which binds together accommodation and convergence. It occasionally happens that, without any surgical intervention, a convergent squint with hypermetropia in a child is changed so as to become later on in life a divergent strabismus, the hypermetropia remaining the same, only more of that part of it which is latent becoming manifest.

Although some refractive error—usually, as above stated, myopia or myopic astigmatism—accompanies in nearly every case divergent strabismus, a few cases occur exceptionally, where the eyes are emmetropic, just as is the case with convergent squint. Here we have to consider other causes besides those connected intimately with refractive anomalies. As regards divergent cases, bear in mind any factor which might weaken or abolish the natural innervation producing convergence. There is generally found to be some inequality of the visual acuity of the two eyes, only at most a feeble desire for fusion of retinal images, and also we discover that there exists in such cases cerebral and hereditary causes, independent of those lesions that produce ocular paralysis, the squint due to this latter

condition being non-comitant, and altogether of a different character. Cerebral causes, existing in early infancy, may produce divergent squint by altering the visual acuity of one of the eyes, no refractive error existing in either of them. Congenital syphilis is generally the cause, the brain tissue being profoundly affected, and in these cases we nearly always see nystagmus. Even if by external observation it is not apparent, the characteristic oscillations are usually seen on looking at the optic discs.

Any modification in the visual field that happens to be associated with strabismus, either convergent or divergent—other reasons for that modification being excluded—is due altogether to the deviation itself, and is therefore quite a secondary phenomenon.

Treatment of Divergent Squint. — This consists primarily in exactly correcting whatever error of refraction may exist, especially in the myopic cases. They should be encouraged to wear the glasses always, both for near and distant vision. At first they may complain of the small size everything is, especially while looking at near objects and when reading small print. Those myopes who first begin their glasses in adult life generally require a rather weaker pair for reading, about 1 or 2 diopters less. A disappearance of the squint is soon brought about in fairly recent cases by the clear vision afforded by means of these spectacles. Children do not need the weaker reading glasses, as they very soon accustom their eyes to the one pair, using them constantly. Operation only becomes necessary in those cases which have been of long standing, and where spectacles have failed. The extremely rare cases, where there is no ametropia to correct, must be dealt with on general principles, and according to whatever may be found to be the underlying cause, such as congenital syphilis, etc.

Neuropathic Divergent Squint. — Many of the cases described by authors as having no associated error of refraction undoubtedly are of this variety. We at once see that the patient before us is of a very nervous temperament. There is no mistaking the marked neurotic element

in the case. The squint has generally existed from quite early infancy. Often we find a family history of chorea, epilepsy, or insanity, and the same kind of squint exists in several other members of the family. From time to time the squint is noticed to vary. It is often alternating. In the unilateral and constant cases the sense of fusion is entirely absent, and amblyopia exists, which is either congenital or acquired. There is no satisfactory treatment for these neuropathic divergent squint cases. Operation is the only thing that gives any hope of improvement (*vide* Chapter IX.). Attempts at fusion-training may be made, but it is seldom that these are of any avail.

The non-comitant divergent squint cases which are not due to paralysis are those of (1) extreme myopia, (2) the divergence of blind eyes, (3) divergence following tenotomy for a convergent squint. In the cases of extreme myopia the cause undoubtedly is a mechanical one, the egg-shaped eyes adapting their long axes to the divergent position of the orbits. The arcs of rotation of each eye are subnormal in all directions. When both the eyes are blind they are nearly always divergent. The state of its refraction, if one eye sees, will determine its fellow-eye's position. Supposing the latter to be blind, for example, the seeing eye, being hypermetropic, causes its blind fellow-eye to converge; but supposing the seeing eye were emmetropic or myopic, its blind fellow-eye would probably diverge.

CHAPTER IX

THE OPERATIVE TREATMENT OF SQUINT

Dr. Felix Terrien, in his exhaustive work on the surgery of the eye, speaking generally of all the operations that are practised on the ocular muscles, states that they have for their sole object the straightening of one or both eyes, when the two visual axes are at fault, these not properly converging towards the point of fixation (strabismus). There is not the slightest idea of performing an operation in the hope of improving vision of the deviating eye or preventing amblyopia, and this may only happen accidentally, as it were, through the eye being more exercised after the operation. Surgical intervention is the more often necessary when the deviation is that of a purely functional disorder, as we know is the case in comitant strabismus, although we have seen the affection is cerebral or psychical, and not muscular, the seat of the trouble probably being in the cerebral co-ordinating centres. A non-comitant deviation, distinctly the result of ocular paralysis, on the other hand, is often quite transitory, and it is generally caused by nuclear lesions, the underlying diseases which cause the lesion being tabes dorsalis, syphilis, toxæmiæ, etc. These call for medical treatment (which is useless in comitant squint), and only is there need for surgical intervention when the paralytic deviation becomes firmly established and well defined, the diplopia giving rise to great discomfort to the patient. One should be exceedingly sparing of operations in cases of paralytic deviation, and they should certainly be avoided at the onset of the affection.

Both divergent and convergent strabismus may be regarded as disorders of convergence. In the one case there is a lack and in the other an excess of convergence, and since the centre of convergence is single, strabismus, or comitant squint, is a bilateral affection. It is well that this fact should be borne carefully in mind, as it explains why it is good practice in many cases to operate on both the eyes. Even Panas, although he adhered to the mechanical muscle theory, supported this practice. He explains it as follows (*loc. cit.*) : " The surgical intervention should be bilateral, because to all loss of bilateral balance there should be applied an equal bilateral correcting action." Panas, however, considered that tenotomy acted in remedying a supposed shortness of the muscle by setting it farther back from its insertion. " This fundamental error," writes Parinaud, " is the principal reason for the uncertainty of the surgical treatment of squint." This author insists on the fact that squint at its commencement is characterized by a disorder of the innervation of convergence, and that it can remain for a long time in the condition simply of a nervous trouble. Tenotomy does not act favourably because of any removal of a mechanical obstacle, since such an obstacle has no existence. The operation, however, is wonderfully efficacious, its effect being marked especially in convergent squint. A mechanical obstacle, if it existed, could not be removed by chloroform, and yet this nearly always causes the strabismus entirely to disappear. Parinaud believes that the operation simply acts by weakening the muscle, the insertion of which is set farther back, thus counterbalancing the perversion of innervation. " One immediately sees," says Parinaud, " that tenotomy, although it remedies a nervous trouble, is not applied directly to the cause of the deviation, which has its seat in the brain. It brings an amelioration about by indirect action, and we easily perceive how difficult it becomes to gauge in any degree the operative effect."

Operation always should be regarded as only a part of the treatment of squint. It is especially important that the patient should continue wearing the spectacles which

correct his refractive error. These, however, after the operation, may need to be somewhat modified. Operation ought not to supplant orthoptic treatment, but it may often supplement it. Even after the operation the treatment is far from being finished. In some cases, to ensure success, it should be regarded only as a commencement—a foundation upon which to build up the cure. The eyes have been brought by the operation into a favourable relative position for a course of orthoptic training. Indeed, those who have studied the subject from the orthoptic side, and who are the most enthusiastic about it, say that when an operation is really needed the earlier in life it is done the better, so that the eyes will be in the more favourable position for developing the fusion faculty by orthoptic measures afterwards. The best age for operation in a convergent squint case, however, is a very difficult question to settle, and there is a great diversity of opinions on this subject. If, as is really the case, a cure of a marked case of squint in a young child can be effected by orthoptic measures, we may well ask the question, What are the clear indications for operation, and at what age are they the most urgently indicated? It seems to be rather a matter of expediency in a good many cases. Operations on the muscles of young children's eyes have to be performed with a local anæsthetic, such as cocaine, to see the effect. This does not act deeply enough to prevent the patient feeling a little pain, which is magnified enormously by the state of fear and nervous apprehension in which the child is in. If the little patient's friends are told, as I think they should be, that the operation is only to be a foundation for further non-operative treatment—a placing of the eyes into position for their harmonious binocular exercise afterwards by means of orthoptic measures—these friends, unless they are very intelligent and made to carefully understand, will certainly think the operation unnecessary. Because of success in some cases, too much is expected from operation by itself, and then if it is not a complete success the child's parents are disappointed, and not likely to be hopeful regarding other measures that are more or less tedious and

gradual in their action. After carefully weighing all the pros and cons, I am inclined to agree with Dr. Felix Terrien, who lays it down that operation should not, as a rule, be performed for squint until the patients have reached the age of nine years; orthoptic measures having been tried before the operation, and, without the operation, having failed. If some amount of binocular vision has been gained before the operation, or amblyopia conquered, so much the more hope of success after the operation. Fuchs advises the delay of operation for convergent squint until the child is over ten years of age. He says: "Since the strabismus in some cases, although rarely, disappears of itself as the children become older, it is advisable to delay the performance of the operation until the child has passed the age of ten; for if we should perform early tenotomy in a case which has a tendency to become well spontaneously, a divergent strabismus would subsequently set in." This sound advice was written in his text-book by the great Austrian oculist long before Javal and Parinaud introduced orthoptic measures in the treatment of squint, when there was nothing else thought of in Vienna but, as Fuchs further counsels, while waiting, to "keep the deflected eye in constant practice by frequently bandaging the other," "to wear the proper convex glasses," etc. (*vide* Chapter VII.). Now, with persevering orthoptic treatment, especially under the age of seven, strabismus, instead of rarely, may be said to commonly disappear of itself—in other words, it is cured by the development of the fusion faculty and the firm establishment of binocular vision.

Before going on to describe the operations that are performed, it is necessary to state what are the clear indications for each operation according to the kind and degree of the strabismus. In a divergent squint needing operation an advancement of the internal rectus is by far the best operation. This is generally performed with tenotomy of the external rectus, and with a very large amount of divergence it is best to even operate on both eyes, not always at one sitting, but doing the combined operation on the other eye subsequently. A convenient modification of the linear

method for determining what to do is especially useful for the operations of convergent cases. This modification is arrived at by means of Hirschberg's method of measuring the angle of deviation (*vide* Chapter VI.). We have five groups of cases: Group I. (Fig. 30, representing the right eye), in which the reflex is nearer to the centre than to the

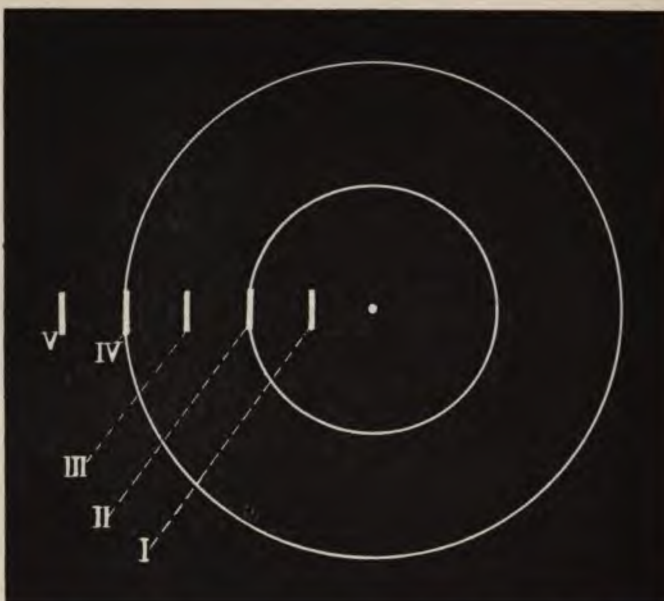


FIG. 30.—DIAGRAM REPRESENTING VARIOUS DEGREES OF SQUINT.

The inner circle represents the margin of a medium-sized pupil; the outer circle represents the margin of the cornea. Compare this with Fig. 11.

margin of the pupil. It is less than 10 degrees of deviation, and no operation is necessary. Group II., in which the reflex is at the margin of the pupil, and the angle is about 15 degrees. A simple tenotomy is necessary, with occasionally a tenotomy of the other internal rectus. Group III., in which the reflex is outside the margin of the pupil, about halfway between the centre of the pupil and the corneal margin. This represents a strabismus of about 25 degrees, and indicates a tenotomy of the internal rectus combined with a moderate

advancement of the external rectus. Occasionally, later on, a tenotomy of the other internal rectus will be required. Group IV., in which the reflex is on or near the corneal margin. This represents a deviation of about 45 to 50 degrees, and it indicates a tenotomy of the internal rectus, along with energetic advancement of the external rectus, with sometimes a later tenotomy of the other internal rectus. Group V., in which the reflex is on the sclerotic, between the margin of the cornea and the equator bulbi. This shows a deviation of at least 60 degrees, and it requires the combined operation with the strongest possible advancement of the external rectus. Sometimes a tenotomy of the other internal rectus, and even the combined operation on the other eye, may be necessary, generally performed later. "Since," writes Swanzy, "concomitant strabismus is the result of a faulty innervation, and not due to a muscular defect, rules which will ensure in every case, with absolute certainty, the desired degree of operative effect cannot be laid down. The following will be found to answer in the majority of cases, and if the effect be now and then too great, it can be adjusted by bringing forward the internal rectus, or by setting back the external rectus, within a few days after the operation. When the fusion sense is very defective, it is safer to leave 2 or 3 degrees of convergence, for the effect of the operation is apt to increase within a year, and if absolute parallelism be present at first divergence may ultimately supervene. The establishment of binocular vision, when it is possible, would do away with this remnant of strabismus, and under any circumstances this remnant does not detract from the cosmetic result.

"If the vision of the squinting eye be fairly good, and the deviation amount to not more than 15 to 20 degrees, and the power of the external rectus be sufficient, the correction can be effected by tenotomy of the internal rectus of the squinting eye. A strabismus of 20 degrees will require the free separation of the delicate connexions between the anterior surface of the tendon or capsule of Tenon and the conjunctiva as far back as the caruncle, in order that the tendon may be free to contract. For a

deviation of 15 degrees or less this separation should not be so free, or should be quite omitted; or, if a very slight effect be desired, it can be produced by drawing the conjunctival wound together, after an operation which has been confined strictly to the insertion of the tendon.

"If the vision of the squinting eye be fairly good, and the power of the external rectus sufficient, and if the squint be more than 20 degrees, it is advisable to divide the proceeding between the two eyes—*e.g.*, if it be 30 degrees, about 15 to 20 degrees are corrected by tenotomy of the internal rectus of the squinting eye, and the remainder by tenotomy of the internal rectus of the fixing eye. If desired, the effect of the tenotomy in one or both eyes may be increased by a suture passed through a fold of conjunctiva at the outer side of the globe and tied tightly. A double tenotomy is liable to damage the power of convergence, hence some prefer advancement of the external rectus of the squinting eye.

"If, although the vision of the squinting eye be good, and the deviation not more than 20 or 25 degrees, there be marked loss of power of the external rectus muscle, tenotomy of the internal rectus must be combined with advancement of the external rectus of the squinting eye. But advancements in such cases as this must be cautiously carried out, as an excessive effect may easily be produced. The external rectus should be but slightly brought forward.

"If the deviation exceed 35 degrees—even when there is good vision in the squinting eye, and no loss of power in the external rectus—tenotomy of the internal rectus of each eye is rarely sufficient, and, as a rule, advancement of the external rectus of the squinting eye must be combined with these measures.

"With a deviation of 30 to 35 degrees, and loss of power in the external rectus, the demand for advancement of the external iectus becomes more imperative. The correction of squints of 40 degrees and more are, in every instance, to be effected by tenotomy, with vigorous advancement, in the squinting eye, and subsequently tenotomy of the internal rectus in the good eye.

"In cases where the vision of the squinting eye is much reduced, the deviation great, and the insufficiency of the external rectus marked, the combined operation in one or both eyes is the proper proceeding."

I have made a lengthy quotation from Swanzy, giving all the above rules, as it appears to me that if operation is decided upon in any case one cannot do better than strictly adhere to them. The element of uncertainty in operating on the ocular muscles, especially as regards after-year developments, all the more shows that the surgeon needs something tangible in the way of precise rules to guide him, founded on the extensive experience of the best operators.

The two operations for squint are—(1) tenotomy, and (2) advancement.

1. **Tenotomy.**—The internal rectus is the muscle that is generally tenotomized. The tendons of the other muscles are divided in a somewhat similar fashion, so that the one description will do for all. The eye is rendered as aseptic as it is possible to make it. The operation is not very painful, and a local anæsthetic, well applied—usually cocaine, 1 or 2 per cent.—will suffice. It is best to cocainize both eyes, and also instil one or two drops of Parke Davis and Co.'s adrenalin (1 in 10,000). Some foreign authorities have advised the injection of the cocaine under the conjunctiva, but Terrien, although rather in favour of this proceeding, admits that great inconvenience results from it, on account of the œdema that it causes. It is enough to instil cocaine or adrenalin during the operation from time to time, as is deemed necessary, both in this simpler and shorter operation and in that of the more tedious advancement operation. The adrenalin stops the bleeding, and assists the action of the cocaine. If a safer local anæsthetic than cocaine is at hand, and it is felt that it can be trusted, so much the better. I have lately been very pleased with novocain as a local anæsthetic. Another new local anæsthetic that has been used latterly in Paris is called stovaïne. Holocain and tropococain are both used in America. The instruments should be thoroughly sterilized. They are four in number: (1) the eye speculum; (2) fixation forceps; (3) blunt-pointed

straight scissors; (4) strabismus hook. The operator is behind and slightly to the right of his patient if he is going to operate on the right eye, and in front and to the left of his patient if the left internal rectus muscle is the one that he intends to tenotomize. The speculum is placed in position, care being taken that it is well fixed. The patient is told to look well in the opposite direction, and to keep his eyes fixed upon some object at a little distance away. By means of the fixation forceps a horizontal fold of the conjunctiva is raised on the inner side, and at about 4 millimetres' distance from the cornea, the forceps being held in the left hand. Then, holding the scissors in the right hand, the surgeon makes, with a single snip, a vertical incision. This incision is just a shade nearer the cornea than the actual insertion of the tendon that is to be cut. The incision is slightly enlarged above and below, and the conjunctiva is undermined internally. This is done by inserting the points of the closed scissors into the wound, and with a snipping action making a passage through the subconjunctival tissue from the opening in the conjunctiva to the upper border of the tendon if operating on the left eye, and to the lower border of the tendon if operating on the right eye. The strabismus hook is now exchanged for the scissors, and this is introduced under the tendon, care being taken that the point of the hook is kept in contact with the sclerotic. The whole breadth of the tendon should lie over the hook, but care should be taken to cause no pain by any dragging with the hook. Some surgeons seize the tendon with the forceps instead of using the hook, but this proceeding is likely to cause pain. They have to drag forward the tendon, which is painful; but it certainly has the advantage of being a ready way of at once getting a good hold on the tendon. One blade of the scissors is now introduced by the side of the hook or the forceps, and the tendon is cut close to its insertion. If the hook is used it comes away as soon as the tendon is divided, and must be then again introduced and moved about, so as to find and divide any fibres of connective tissue, which, if allowed to remain, would still keep the tendon in its place, and thus hinder the

operation from having the desired effect. Only the fibres in the immediate neighbourhood of the tendon should be divided ; the portions of the capsule of Tenon, above and below, which form the check ligaments, should on no account be cut. It is best not to suture the conjunctiva, except when the incision has been made unusually large. A test should be made after the tendon has been cut, so as to note the effect of the operation. Ask the patient to look to the side that has been operated on. If, when he looks inward —*i.e.*, when the internal rectus tendon has been divided— the eye turns in as it did before, there still remain strands which need dividing. The eyes are made to converge by telling the patient to look at a finger held in front. The finger, gradually brought nearer and nearer, ought to reach 12 centimetres before the eye halts. If the eye operated on halts before 12 centimetres is reached, this argues an excessive effect of the operation and the danger of a divergent squint developing. Under these circumstances a sutuie to counteract this effect is inserted.

A better way of testing the effect is by means of prisms. The average effect of tenotomy on the internal rectus is about 13 degrees, and on the other recti muscles it is about half this amount. However, this varies considerably, and the effect of the operation after a time diminishes somewhat. For about forty-eight hours a pad and bandage should be worn, but no longer. The eye should be bathed with boric acid lotion five or six times a day, which keeps it clean and promotes the healing. It is a very rare occurrence for much hæmorrhage to complicate this little operation. It occurs, however, in quite exceptional cases, such as in hæmophiles, or when some rather large anterior ciliary vessels are wounded. Extravasation of blood into Tenon's capsule suddenly causes an extreme protrusion of the eyeball. This can be easily remedied by compression with a bandage, the hæmorrhage being stopped with great facility, but the operation has to be postponed. An accident of this kind can nearly always be avoided by freely using adrenalin, and also by taking care always to make the conjunctival wound quite near to the limbus. The only other com-

plication is that of wounding the sclera. This is rendered an impossibility by the use of blunt-pointed scissors. Some surgeons prefer to use small curved scissors, but there does not seem any special advantage in their being curved; straight scissors answer quite as well.

A sunken caruncle is observed as an after-effect where there has been considerable retraction of the muscle. In order to avoid this it is recommended to divide any fibrous premuscular expansions on the outer aspect of the muscle before the tenotomy, so that the muscle in retracting will not drag the caruncle in. If it has been advisable to do this, it is always best to finish by inserting a conjunctival suture.

A rare after-effect is the widening of the palpebral fissure, with slight exophthalmos. If this continues to form a disfigurement, it may be remedied by external tarsorrhaphy of the same side, or by a slight canthoplasty of the opposite side, so as to equalize the two palpebral openings; but it is extremely rare that anything need be done. A slight fleshy button may remain for a considerable time, but this gradually disappears, although the retraction of the tissue reduces the effect of the tenotomy. Diplopia occurring after the operation is a good sign, as it promises well for the re-establishment of binocular vision.

2. **Advancement.**—There are several ways of doing this operation. The principal difficulty is that of the sutures—that they should hold perfectly and not give in the slightest. Worth's method of doing the operation appears to be one of the best, as the circulation is not interfered with by the sutures that are applied to the cut end of the tendon. He takes great care in preparing his sutures, so that they should be thoroughly sterilized, should be easy to work, should not cut their way through, and should firmly hold. The operation is described by him as follows:

"The surgeon, standing behind the patient's head, grasps the conjunctiva with the toothed forceps, while with the scissors he makes a straight vertical incision through it about ½ inch long. The middle of the incision is close to the corneal margin. A similar incision is then made through

the capsule of Tenon. The conjunctiva and capsule then retract, or, if necessary, they are pushed back, so as to expose the insertion of the tendon. If the angle of the squint is of high degree, the vertical incision through the membranes is made curved instead of straight, the convexity of the curves being towards the cornea. This is to allow the membranes to retract more freely. One blade of the advancement forceps is now passed under the tendon, after the manner of a tenotomy hook, the other blade being superficial to the conjunctiva. The forceps is now closed, so that tendon, capsule of Tenon, and conjunctiva are all firmly clamped together, with their relations undisturbed except for the retraction of the membranes. The tendon and a few little fibrous bands beneath the tendon are now divided with scissors at their insertion into the sclerotic. The advancement forceps, holding the tendon, capsule, and conjunctiva, can now easily be lifted up so as to get a good view of the under side of the muscle.

"One of the needles is then passed inwards at A (Fig. 31), through conjunctiva, capsule, and muscle. It is then again passed through muscle, capsule, and conjunctiva, and brought out at B. The bight of the thread thus encloses about the lower fourth of the width of the muscle, together with its tendinous expansions, capsule and conjunctiva. The other needle is similarly entered at A′, passed through conjunctiva, capsule, and muscle, and brought out at the under side of the muscle. It is then entered again at the under side of the muscle, and brought out through the conjunctiva at B′, the bight of this suture thus enclosing the upper fourth of the width of the muscle, etc. The object of inserting both sutures before proceeding further with either is that they may be symmetrically placed. The ends of the thread from A′ and B′ are then knotted tightly at C. The end bearing the needle is then entered at D, and passed through conjunctiva, capsule, and muscle, and carried beneath the lower blade of the advancement forceps nearly to the corneal margin. The needle is here passed through the tough circumcorneal fibrous tissue, and brought out at G′. The two ends of the thread are then temporarily tied

together loosely, with a single hitch at H. The first suture is then similarly completed. The anterior part of the muscle and capsule and conjunctiva are then removed by cutting them through with scissors behind where they are grasped by the advancement forceps. The gap is then closed by tightening and securely tying each suture at HH,

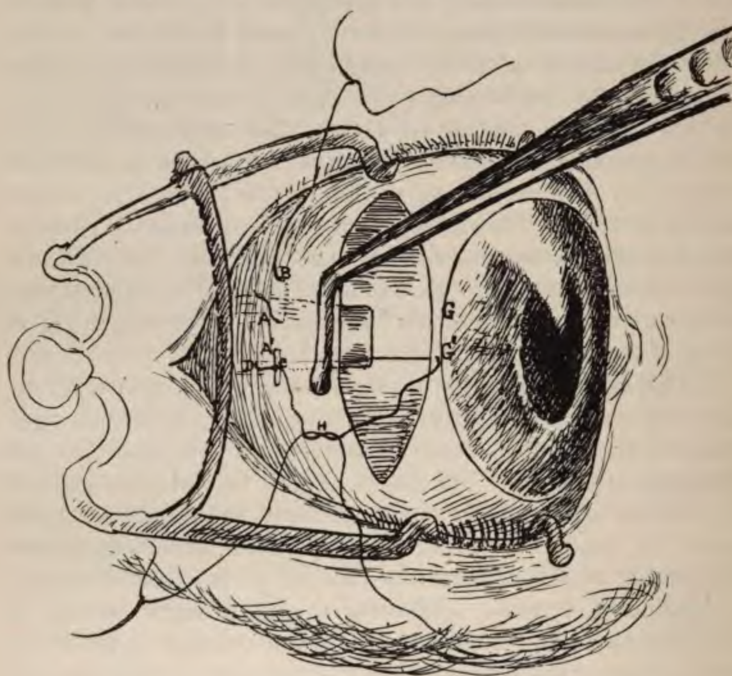


FIG. 31.—WORTH'S METHOD OF ADVANCEMENT.

so that the eyeball is rotated in its correct position, and the anterior end of the muscle is brought nearly up to the corneal margin at GG′.

"In operating under cocaine, before the knots are tied at HH an assistant holds the globe in the primary position with forceps, while the patient is told to try to look away from the operated muscle. This relaxes the muscle while it is being held forward by the sutures. The sutures are then temporarily secured at HH by the first hitch of the

surgeon's knot. The assistant then releases the globe. The fine adjustment is done by tightening or loosening the hitches at HH, the result being checked by the mirror-tests or by the reflection of a candle-flame on the cornea. The surgeon's knots at HH are then completed.

"In operating under cocaine, the immediate effect is the permanent result. No over-correction, therefore, is necessary. In operating under general anæsthesia one has to bear in mind the angle of the deviation, and produce approximately that degree of rotation."

A little boric acid ointment should be applied to the edges of the lids to prevent them from sticking together, the eye having been gently irrigated with sterilized saline solution. Then a gauze pad and bandage are applied. Both eyes must be bandaged. The after-treatment is important. It consists in keeping the patient in bed for about five days with both eyes bandaged. The eye is irrigated, and fresh dressing applied every day. After the fifth day, the eye that has not been operated on may be uncovered, but accommodation needs to be prevented in this eye, atropine drops being instilled in it for this purpose. If the patient wears spectacles, they may be put on over the bandage, and on the lens before the unoperated eye two pieces of postage-stamp or black paper is to be applied, so that the patient can only look through a median vertical clear part of the lens between them ; lateral movements of the eye are thus prevented. On the eighth day the stitches can be removed, and two days after that the bandage.

In some cases it is advisable to bring forward the capsule of Tenon and the conjunctiva, as well as the enfeebled muscle. This is easily done by clamping them together in the advancement forceps. An opening sufficiently large to introduce a blade of the advancement forceps is made with the scissors through the conjunctiva and capsule of Tenon, just above and below the insertion of the muscle, and thus the two membranes with the muscle are seized. The long vertical incision is then made near the corneal margin, and the operation proceeded with as above. This modification of the first part of the operation is necessary

in some old cases of divergence following tenotomy of an internal rectus. Also many cases of neuropathic divergence are treated in this way.

A secondary advancement of an internal rectus that has retracted is made usually in the ordinary way, it not being necessary to do a musculo-capsular advancement. "After tenotomy, the tendon fails to become reattached directly to the globe far more often than is generally supposed. If the muscle be fairly good, it may be advanced in the usual way. If, however, it be much atrophied, a musculo-capsular advancement is to be preferred."

The suture material used is a most important detail. It must not be thin, or it will cut through the tissues like a knife. Thick black silk is the best. It can be prepared as follows : "A reel of the silk is wound loosely round a winder (made by bending a piece of wire). It is boiled in water to sterilize it and remove the superfluous colouring matter. It is then dried before the fire. The end of the silk is threaded through a large glass bead, which is then dropped into a glass beaker containing a very hot mixture of white beeswax (three parts) and white vaseline (five parts). The whole of the silk is drawn through the boiling mixture, and is wound on a large glass reel. It is kept in a sterilized glass jar, always ready for use without further preparation." This thread is stiff enough at the ordinary temperature of the air to abstain from tying itself into undesirable knots during the operation, but at the body temperature it is quite supple.

The needles should be as sharp as possible. It is easy to keep them sharpened with the use of a fine oilstone. By keeping them in a flannel book their delicate points are protected from injury. The kind of needles is a matter of taste. They should, of course, be curved. For my own part, I rather prefer the French needles to the English ones. They are easier to thread, being open above, so that the thread needs simply to be slipped over the top. It is easy to quickly thread them in the middle of an operation. The same kind of needles are used at Vienna, in Fuchs' clinic, and I believe elsewhere on the Continent. They may be obtained by writing to Messrs. Luër, Rue Antoine-Dubois, Paris, or any of the other good instrument-makers on the Continent.

PART II

OCULAR PARALYSIS

CHAPTER X

THE ANATOMY AND PHYSIOLOGY OF THE EXTRINSIC MUSCLES

PRECISE knowledge of the anatomy and physiology of the six muscles that move the eyeball is an absolute necessity for an accurate conception of the phenomena connected with ocular paralysis. The six muscles comprise the four recti or straight ones, and the two obliques. These are best considered in pairs, one of each of the pairs having an antagonistic action to its fellow. The four straight muscles are directed from behind forwards. Regarding the tendon of the superior oblique as if it were the whole muscle, the obliques may be considered as having a somewhat opposite direction—*i.e.*, from before backwards, so that if all four recti acting together were to pull the eye backward into the socket, the obliques would tend rather to pull it forward again. Of course this action of the four straight muscles could not take place, owing to the admirable arrangement of the fascia, Tenon's capsule, and the check ligaments ; but the idea is given to show clearly the relation of the obliques, generally speaking, to the recti muscles. The lateral pair of recti muscles (external and internal recti) have an extremely simple action—namely, that of abduction and adduction.

As the obliques are the most complicated of all, it will be better if we take them first, thoroughly mastering the details

of their position and action before going on to consider the two remaining pairs of ocular muscles—*i.e.*, the four recti.

The Superior Oblique Muscle arises from the orbital roof at the upper and inner margins of the optic foramen. It differs from every other muscle of the human body in having its comparatively long tendon bent backwards at a somewhat acute angle to the direction of its fleshy belly.

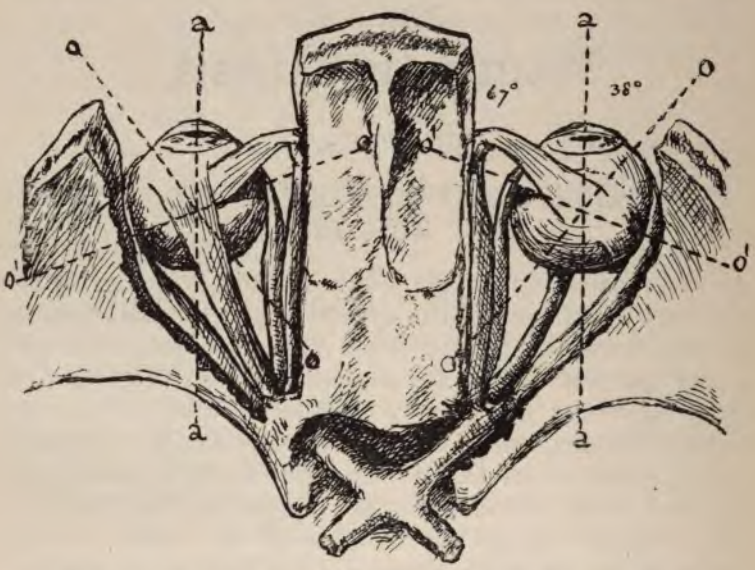


FIG. 32.—OCULAR MUSCLES FROM ABOVE (NORTON) GIVING AXES OF OCULAR MOVEMENTS.

oo, Axes of oblique muscles; *aa*, visual axes; *o'o'*, axes of superior and inferior recti.

This latter runs along the upper and inner part of the orbital wall above the internal rectus muscle. Before it passes through the trochlea or ring-like pulley it narrows into a smooth, round, shining, and slender tendon. It then passes through the pulley, which occupies a little fossa within the supra-orbital margin above the internal angular process, the little pulley called the trochlea being attached firmly to this part of the frontal bone. There is no other muscle which has a pulley arrangement such as this, causing

the tendon to be bent on itself at an angle so as to completely alter the direction of the muscle. The tendon now has changed its course—instead of being directly forwards it is turned so as to have an outward, backward, and somewhat downward direction. It then forms a fanlike expansion over the upper part of the eyeball, passing obliquely

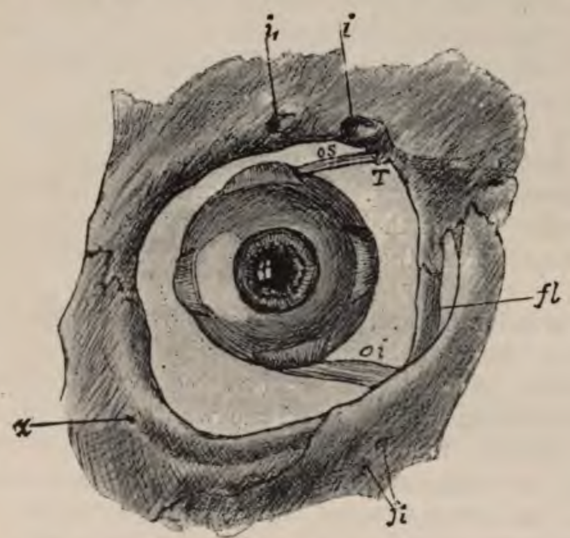


FIG. 33.—ANTERIOR ORIFICE OF ORBIT SHOWING EYEBALL (AFTER FUCHS). NATURAL SIZE.

The tendons of the four recti muscles are cut off near their insertions upon the eyeball, but the inferior oblique *oi* and the tendon *os* of the superior oblique are left entire; the latter comes from the loop of the trochlea *T*; to the temporal side of the trochlea lies the supra-orbital notch *i*, and somewhat to the outside of this there is a foramen i_1, which is not regularly present, for a branch of the supra-orbital nerve; *fl*, lachrymal fossa; *fi*, infra-orbital foramina; *z*, orifice of the zygomatico-facial canal.

under the superior rectus, and ending by being inserted into the sclera, behind the equator, and therefore behind the transverse axis of rotation; this insertion being exactly between the entrance of the optic nerve and the cornea, and midway between the superior rectus above and external rectus below. It is obvious that because of this arrangement the action is a powerful leverage one in a direction

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opposite to that which it would have had supposing the whole of the muscle had continued in a straight course. If straightened out, considerably more than the anterior half is seen to be tendon.

Action.—Owing to the position of its insertion, it helps the inferior rectus muscle to draw downwards the cornea. It has, with the inferior oblique, an auxiliary abductive action. Assisted by the superior rectus, it circumrotates the eyeball from above inwardly, opposing the action of the inferior rectus and inferior oblique, both of which act together in circumrotating from below outwardly. This wheel-like movement round a fore and aft axis is, of course, very limited in extent. It is important to remember the combined action of the two obliques as accessory abductors —in other words, they assist the action of the external rectus.

The Inferior Oblique Muscle arises by a flat tendon from the orbital plate of the superior maxilla to the outer side of the orbital orifice of the lachrymal duct. It passes outwards, somewhat upwards and backwards, below the inferior rectus muscle, this structure lying between it and the eyeball; it then continues upwards, wrapping round the eyeball, and being situated between that structure and the external rectus muscle. It is somewhat like a long, slender hand, with the eyeball and inferior rectus lying lightly in its grasp, the wrist corresponding to its origin, and the finger-tips to its insertion, passing obliquely outwards and backwards from the inner front, the hollow of the hand looking upwards and inwards. It ends in a membranous expanded tendon, which is inserted into the sclera on the upper and outer posterior quadrant of the eyeball, immediately below and external to the insertion of the superior oblique muscle.

Action.—It has a similar action to the superior oblique as regards abduction, but in every other respect their actions are opposite. It rotates the eyeball. Except it be displaced abnormally by some pathological process, the eyeball as a whole never undergoes any change of position. All its movements are round a point approximately correspond-

ing to the centre of the eye. Those movements that take place in the horizontal plane around a vertical axis passing through this centre are spoken of as abduction and adduction. Rotation is a term usually applied to the wheel-like movements round the sagittal or fore and aft axis. Circumrotation is perhaps the better term. J. Herbert Fisher describes (*loc. cit.*) the action of these muscles as follows: "In considering the action of the superior and inferior oblique muscles we have to recollect that the latter in its whole length and the tendon of the former from its pulley run backwards and outwards, to be inserted on the postero-external quadrant of the globe near to its posterior pole, and that the angle which each muscle makes with the antero-posterior axis is about 51 degrees. Remembering, then, that the superior oblique descends from the roof, and that the inferior oblique ascends from the floor, it is easy to see that the actions may be briefly expressed as—

"External rectus: abductor.
Superior oblique: depressor, abductor, internal rotator.
Inferior oblique: elevator, abductor, external rotator."

The Recti Muscles.—We had better consider the superior and inferior pair, and then the external and internal pair of muscles.

The Superior Rectus arises from the upper portion of the anterior margin of the optic foramen. As it passes forwards it broadens, to be inserted by a thin expanded tendon into the sclera about 7 millimetres behind the upper margin of the sclero-corneal junction. It lies between two important structures—the levator palpebræ superioris muscle above, and the optic nerve below. With the other three straight muscles it helps to form a sort of muscular funnel or hollow cone, the apex of which is the optic foramen, the base containing the globe of the eye, and the axis the optic nerve.

Action.—Assisted by the inferior oblique muscle, it causes the eye to look upwards. With the inferior rectus it forms an accessory adductor, assisting the internal rectus muscle. It circumrotates the cornea slightly inwards, assisting in

8—2

this the action of the superior oblique. We may compare the supplementary adductor action of the superior and inferior recti to the combined action of the flexor carpi ulnaris with the extensor carpi ulnaris in producing adduction or ulnar flexion of the hand upon the forearm.

The Inferior Rectus arises from the lower margin of the optic foramen, through an incomplete fibrous ring termed the ligament of Zinn, which surrounds the foramen except at its upper and outer part. The muscle passes forward along the floor of the orbit and below the optic nerve, and is inserted into the sclera about 6 millimetres below the lower margin of the cornea.

Action.—Assisted by the superior oblique muscle, it causes the eye to look down—*i.e.*, it depresses the cornea. It also is an accessory adductor, and it circumrotates the cornea slightly outwards.

The External Rectus Muscle is seen along the outer wall of the orbit. It has two heads of origin. The upper head arises from the outer margin of the optic foramen, beneath the superior rectus, and the lower head partly from the ligament of Zinn and partly from a small spine of bone situated on the lower margin of the sphenoid fissure. The ophthalmic vein, the third, sixth, and nasal branch of the fifth nerve pass between these two heads. The muscle is inserted by an expanded tendon into the sclera about 6 or 7 millimetres behind the outer margin of the cornea.

Action.—Simply that of abduction.

The Internal Rectus Muscle lies along the inner wall of the orbit, below the superior oblique muscle, ophthalmic artery, and nasal nerve. It arises through the ligament of Zinn from the inner margin of the optic foramen, and is inserted into the sclera about 5 to 6 millimetres behind the inner margin of the cornea.

Action.—Simply that of adduction.

The nerve-supply of the extrinsic ocular muscles is as follows: The upper division of the third nerve (motor oculi), besides supplying the levator palpebræ superioris, supplies the superior rectus muscle; the lower division of the third (motor oculi) supplies the internal and inferior

recti muscles and the inferior oblique. The superior oblique is supplied by the patheticus or fourth nerve, and the external rectus by the abducens or sixth nerve.

The Capsule of Tenon, or Bulbar Fascia.—It is necessary to say a few words concerning this structure. It envelops the posterior four-fifths of the eyeball, and it becomes continuous posteriorly with the sheath (dura matral) of the optic nerve. Therefore the theory that it forms a sort of cup-and-ball arrangement with the globe is untenable.

FIG. 34.—LINES OF INSERTION OF THE FOUR RECTI MUSCLES PROJECTED UPON A PLANE (AFTER FUCHS).

One-third larger than natural size.

I agree with Mr. Fisher, who writes: "Surely the optic nerve cannot play up and down like a piston in its cylinder." He goes on to say: "I regard the globe and capsule as moving harmoniously together upon the retro-ocular tissues—*i.e.*, the fat packing the orbit; this, in the living subject, will be in a semifluid condition. . . . Only by such an arrangement . . . could the retinal and choroidal circulations go on unimpeded in all the different positions into which the eyeball can be turned."

The tendons of the ocular muscles are ensheathed by a sort

of folding back of this bulbar fascia. The openings in the fascia before their insertions are not simple apertures, but like the invaginations of the fingers of a glove, the sheaths, however, not ending, but becoming continuous as the fascia proper of the muscles.

Not only have the muscles of the two eyes to be understood perfectly, and their individual actions clearly kept in mind, but also it is important to rightly appreciate the binocular associated movements of these muscles.

I have endeavoured to show clearly that the six extrinsic eyeball muscles moving the globe (taken singly) around its own centre of rotation each form naturally three antagonistic pairs—the pair of lateral muscles antagonizing each other, the pair of obliques, etc. In considering the two eyes together we come to rather different conditions.

Binocular Movements.

These may either be—(1) parallel associated movements in the horizontal plane; (2) parallel associated movements in the vertical plane; (3) parallel associated movements in an oblique direction, upwards and outwards, upwards and inwards, downwards and outwards, downwards and inwards; or (4) rotatory associated movements in the facial plane.

Those muscles which are not directly concerned in bringing about a movement, whatever that movement may be, serve to steady or assist in guiding the eyeball and prevent overaction. Like every other part of the body, there is equilibrium of movement.

1. **Parallel Associated or Conjugate Movements in the Horizontal Plane**.—When a person looks to the right, the movement of the right eye is that of abduction—*i.e.*, the deviation is away from the mesial line; but the associated movement of the left eye is that of adduction—*i.e.*, the deviation is towards the mesial line. We have, therefore, a conjugate action of right abduction and left adduction; that is, on the right side the right external rectus chiefly comes into action, and on the left side the left internal rectus chiefly acts. The accessory abductors—namely, the right

oblique muscles—and the accessory adductors—the left superior and inferior recti as auxiliaries—also play their part. The reverse of this takes place when a person looks to the left—*i.e.*, left abduction and right adduction.

2. **Parallel Associated or Conjugate Movements in the Vertical Plane.**—When a person looks up, both superior recti muscles act in unison, assisted by both inferior oblique muscles. When he looks down, both inferior recti and superior obliques act together.

3. **Parallel Associated Movements in an Oblique Direction.**—The muscles associated in oblique conjugate deviations are as follows :

Upwards and to the Right.—

Right eye	Superior rectus. Inferior oblique. External rectus.
Left eye	Superior rectus. Inferior oblique. Internal rectus.

Upwards and to the Left.—The same muscles, except that the internal rectus is employed for the right eye, and the external rectus for the left eye, simply the reverse of the other.

Downwards and to the Right.—

Right eye	Inferior rectus. Superior oblique. External rectus.
Left eye	Inferior rectus. Superior oblique. Internal rectus.

Downwards and to the Left.—The same, except that the internal rectus is employed for the right eye, and the external rectus for the left eye.

Convergence of the visual lines results from the associated action of the two internal recti muscles.

4. **Associated Rotatory Movements** are brought about by the superior and inferior recti muscles acting with the

obliques.* This torsion, or wheel-like rotation power (circumrotation or circumduction), is extremely limited under any circumstances, but it is said to be greatest when the eyeball is turned outwards, and least when it is turned inwards; consequently, in associated movements of the two eyeballs the greater power for rotation needs to be restrained, or the one eye turned out, so as to harmonize with the lesser rotatory power of the other turned in. It obviously follows that the two eyeballs are freer to act together in a rotatory manner midway between adduction and abduction—*i.e.*, in the primary position, when the head is erect and the eyes are directed straight forwards towards a distal point on the visual plane.

To understand clearly the movements of the eye we may consider three primary planes and three primary axes, also bearing in mind that these movements are limited to rotations around one centre. This centre Donders found to be 10 millimetres in front of the posterior surface of the sclera and 14 millimetres behind the summit of the cornea. The whole measurement from before backwards of the eyeball is 24 millimetres. In the horizontal plane we have the movements of adduction and abduction; in what we may consider the antero-posterior vertical plane are the movements of supraduction and infraduction—*i.e.*, looking upward and looking downward, and in an approximately transverse vertical plane we have the rotatory or wheel movements (circumduction). Through this centre of rotation is the vertical axis of adduction and abduction. Through this same centre is the transverse axis of the movements of supraduction and infraduction, and through the centre also is the antero-posterior or sagittal axis of the wheel-like movement of circumduction (*vide* Fig. 32). In these movements of the eye we are considering the action of two or three muscles acting together; for even the simple movements in the horizontal have the two obliques assisting the external rectus, both together slightly and equally, and the two recti above

* Voluntary rotation is denied by Maddox and others (*loc. cit.*). For the difficult subject of False Torsion, etc., consult the chapter in his book on the Ocular Motions.

and below in like manner assisting the internal rectus. No muscle acts singly; the inferior oblique acts with the superior rectus in supraduction, and the superior oblique with the inferior rectus in infraduction.

Positions of the Eyeball.—These may be regarded as four in number: (1) the anatomical position of rest; (2) the primary position or functional position of rest; (3) the secondary position, due to movements from the primary position; and (4) the tertiary positions.

1. There are two conditions in which we have the anatomical position of rest—that of death and that of sleep or deep narcosis. When a patient is deeply under an anæsthetic, then the eyeball, left to itself, is in this position. It is due to the form of the orbit, the length and insertion of the optic nerve, and the length of the muscles when deprived of their innervation. It is usually a position of wide divergence; consequently, when an individual is suddenly awakened from a deep sleep, he experiences for a brief moment diplopia, supposing the brain has very quickly become sufficiently awake to notice it, before the eyeballs have assumed parallelism or the functional position of rest.

2. In the functional position of rest the eyes may be said to be held taut by a delicately balanced muscular harness. Normal eyes naturally assume this position—that is why it is termed a position of rest. It is termed "functional" because the use of the eyes produces it.

3. The secondary positions are of two kinds, resulting from movements away from the functional position of rest. These two kinds are:

(*a*) Divergence or convergence of the visual lines.

(*b*) Parallel movements of the visual lines upwards or downwards.

4. The tertiary positions are caused by movements of the eyes in which the lines of vision are convergent and at the same time are directed upwards or downwards. In the movements taking place from one position of the eye to another, Javal demonstrated a slight circumrotatory motion around a visual axis. In this he was confirmed by Helmholtz, although in general physiologists have denied any

circumrotation in the usual normal movements away from and to the primary position of rest.

Protrusion and retraction movements of the eyeballs are pathological.

Function of the Ocular Muscles.—This is to secure single vision with the two eyes, described in Chapter II. as binocular single vision. By means of these muscles the

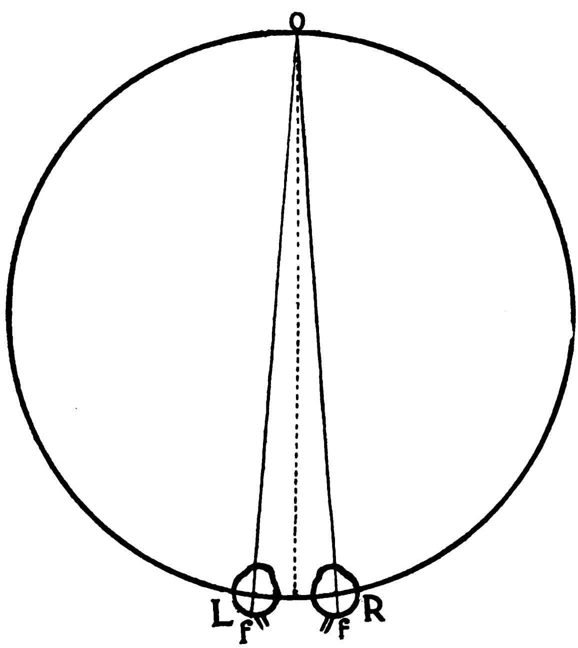

FIG. 35.—DIAGRAM TO ILLUSTRATE THE HOROPTER OF MÜLLER.

R, Right eye; L, left eye; O, object fixed; *ff*, fovea centralis of each eye.

eyes are directed to the point of fixation in such a manner that the image of the object fixed falls simultaneously on the macula lutea of each eye. For single vision all objects should lie in the same horopter, forming images upon the respective retinæ, equidistant from the fovea centralis. The horopter of Müller (Fig. 35) is represented by a circle, which passes through the centres of rotation of each eye and through the apex of the point of fixation of

the visual lines. All objects beyond or inside the horopter will cast images on parts of the retina not equidistant from the fovea, consequently they will create the impression of two objects or double vision. The physiological diplopia, described in Chapter II., and immediately seen with Rémy's diploscope, is thus explained, and may be geometrically demonstrated by means of this horopetric circle.

Orientation.—This is the location of one's position in any given environment, and it depends on the ascription of objects seen to the place where they actually belong. The objects of the external world form images upon the retina. To find exactly the situation of the retinal image of any object, a straight line, passing through the nodal point, must be drawn from the object to the retina. The nodal point of the eye is situated just in front of the centre of the posterior surface of the lens, and is one of the most important points in the schematic eye. All rays of light that pass through this nodal point are unrefracted.

The ascription of objects seen to the place where they actually belong is the result of experience. It is brought about by a psychical process called projection. It has to do with the higher cerebral centres. The retinal image is mentally projected through the nodal point back again to the object. By virtue of this faculty of projection we see the objects of the outside world arranged side by side just as their images are upon the retina, only, of course, in inverse order.

Orientation is objective and subjective. Subjective orientation is purely psychical. It depends on an accurate knowledge that a person has (by means of the sense of equilibrium and the muscle sense) of the position his body occupies in space, and of the position of his eyes within his body. Objective orientation depends entirely upon the appreciation a man should have for the position of objects relative to one another and to his own body.

The question may be asked, What is the difference between projection and orientation? The two are closely allied, but orientation means rather the consciousness we have of the absolute correct positions in space of all objects

seen, as well as of the position of the body relative to those objects; whereas projection, properly speaking, means the referring of any particular object to the extremity of a line which we subconsciously draw from the retinal image of that object through the nodal point of the eye to that object. We may imagine the rods of the retina immediately where the image is enormously prolonged forwards so as to touch the object. "*La vue est le toucher à distance*" (Lagrange). It is important to remember the position of the nodal point in the schematic eye, so as to clearly understand projection.

A double image results from the faulty projection of a deviating eye. Thus, subjective orientation, so far as the deviating eye is concerned, becomes incorrect. The person with the deviating eye makes no allowance mentally for the deviation—in fact, he has no cognizance mentally of it. He therefore projects the image too much to one or other side. The image of the object falsely projected, of course, is on the retina of the deviating eye.

Binocular single vision can only exist when there is true projection of the retinal images of both eyes, and thus orientation is perfect for both.

It will be well here to say a few words concerning diplopia. It is either binocular or monocular. Binocular diplopia is either homonymous or crossed (heteronymous).

Homonymous Diplopia.—When the false image of the object seen by the deviating eye is mentally projected by that eye to its own side, we have what is known as homonymous diplopia. For instance, if the visual line of the left eye be directed on an object, and the right eye converges, the image in the left eye is formed on the fovea centralis; but on the right eye it is not, owing to the deviation formed on the fovea, but it falls instead on the retina, to the inner side, and is projected outwards to the right of the object fixed (Fig. 37).

Heteronymous Diplopia.—On the other hand, if there be divergence of an eye—say the right eye—at the time the visual line of the left eye is directed upon an object, the impression from the object fixed would, in the right eye, fall

upon the retina, to the outer side of the fovea, and when projected outwards would appear to the left of the object fixed, causing crossed (heteronymous) diplopia (Fig. 38). The false image is always the image of the deviating eye. When the eye converges—*i.e.*, deviates inwards—the diplopia is always homonymous; when it diverges—*i.e.*, deviates outwards—the diplopia is always crossed; when upwards, the false image is below; and when downwards, it is above.

Monocular Diplopia can be found to exist when, one eye being closed, the individual experiences the fact that two

FIG. 36.—NORMAL FIELD OF FIXATION (AFTER LANDOLT).

images belonging to one object are formed upon the one retina. Neither may be formed exactly at the fovea, and therefore it may be impossible to call either image the true or the false. These images depend upon some aberration of the visual pathways, and are due to anomalies of the refracting media, a double pupil, etc. Fuchs mentions incipient cataract as a cause, due to the unequal power of different sectors of the lens; but this is more frequently the cause of polyopia, or multiple vision, in the one eye than double vision.

The Field of Fixation.—This is best determined by means of the perimeter, as recommended by Landolt. "The measurement of the excursions of the eyeball," says Fuchs (*loc. cit.*), "is an important matter, not only for physiologists, but also for the ophthalmic practitioner, particularly for the determination of the degree of a paralysis, the progress of its improvement, the prognosis of a squint operation, etc." The field of fixation is determined in the same manner as the visual field, with the one exception of directing the patient to follow the test object with the eye that is being examined. The other eye is covered, and the test object (which may consist of a small printed letter) is moved along the arc of the perimeter. The patient is asked to say when he can no longer tell what the object is, or, in the case of a letter, no longer decipher it. Normally, the eye can be rotated 34 degrees upwards (see Fig. 36) and 57 degrees downwards. The angle of lateral deviation outwards, from the primary or functional position of rest, is 42 degrees; inwards, it is 45 degrees. We see, therefore, that the eye, under normal conditions, is able to turn in a downward direction the most of all, inwards not so much, outwards slightly less, and in the upward direction least of all.

CHAPTER XI

GENERAL SYMPTOMATOLOGY OF OCULAR PARALYSIS

By far the most important symptom that occurs in all cases of ocular paralysis is the double vision (diplopia) ; this not only being important to the patients from their point of view, because of the discomfort it entails, but also to the surgeon, as it forms the principal factor for guiding him to a precise and certain diagnosis of the muscle or muscles affected. We saw in the preceding chapter that diplopia is either binocular or monocular. The latter has no bearing whatever on ocular paralysis ; it need not, therefore, be further discussed. In future the binocular variety is always the one meant whenever the term diplopia is used.

We have already defined also the terms homonymous and heteronymous (crossed) diplopia ; it only remains for us to give a further convenient classification of the symptoms according to the position of the false image and the muscle or muscles affected. This is as follows :

1. Horizontal diplopia (false image upright and parallel).
2. Vertical diplopia (false image upright).
3. Oblique vertical diplopia (false image slanting).

A further subdivision of the last two is :

(*a*) Diplopia in the upper half of the field of vision.
(*b*) Diplopia in the lower half of the field of vision.

The images fall upon dissimilar points of the two retinæ ; they are, in consequence, projected in different parts of the visual field.

The more common varieties are (1) and (3)—the horizontal and the oblique vertical.

1. Horizontal diplopia occurs as the result of paralysis either of abduction or adduction.

2. Upright vertical diplopia—*i.e.*, one image above the other, without any slant of the false one—is extremely rare. It can be induced artificially by a prism, but when it occurs of itself it is strongly suggestive of some orbital tumour pushing the eyeball as a whole upwards or downwards.

3. In the oblique vertical variety the position and slanting direction of the false image is due to the abductor action of the oblique muscles or the adductor action of the recti, together with circumduction—*i.e.*, a wheel-like movement of the muscles (*vide* Chapter X.).

False Projection is the reason for binocular diplopia. When a set of muscles of an eye is unable to act, the eye being unable to follow its fellow in all the various movements, then each eye sees separately an image according as the direction taken by the eyes corresponds with the area of action of the affected muscle or muscles. For example, supposing we have (Fig. 37) the left eye, L, deviating inwards, owing to a paralysis of abduction (external rectus muscle), the object O is seen by the right eye exactly at O, because in that eye the image is formed on the macula *f*; but in the left eye, because of the inward deviation, the image is not formed on the macula *f*', but at a point *b*. Unlike the right eye, the left eye cannot possibly see the object in its true position; it therefore must of necessity falsely project. Habitually seeing all objects that strike the retina at *b* to the left, the object O is falsely projected

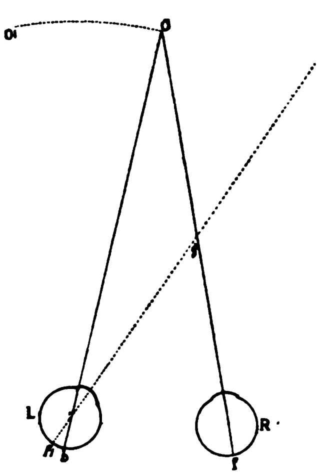

FIG. 37.—HOMONYMOUS DOUBLE IMAGES (AFTER FUCHS).

to O'. The subjective orientation of this eye is not correct; the entire mosaic of retinal images is located in space too far to the left, because the eye is too far to the right. The person who has such a paralysed eye as this naturally has quite a wrong idea of the position it has in his head. We have in the above an example of homonymous diplopia; that is to say, the false image is to the left, or on the same side as the paralysed eye.

In Fig. 38, instead of the left eye being inclined inwards, there is outward deviation through, let us suppose, paralysis of adduction (internal rectus chiefly). The point *b*, where the image of O is situated, is here to the left of the macula *f'*; consequently, there is in this case false projection to the right; O is seen by the eye as if it were at O'. This is heteronymous or crossed diplopia. Habitually expecting the image of the object to be at the macula of the left eye, as well as at that of the right, the patient subjectively has no cognizance of the altered position of his left eye, and he therefore projects too far to the right.

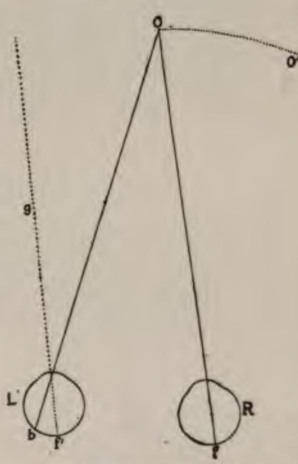

FIG. 38.—CROSSED DOUBLE IMAGES (AFTER FUCHS).

In order to fix well in the memory the fact that *ad*duction is paralysed in *crossed* diplopia, it may be a help to the student to think of the word *crusade*.

When one eye deviates upwards or downwards we have, in the same way, a difference in the levels of the images. In Fig. 39 *b* represents the point where O strikes the retina of the left eye above the macula *f'*, and here there is false projection of the object downwards at O'. If it were a downward deviation, *b* would be below *f'*, and the false projection would be upwards.

The vertical or the lateral separation of the images is in every case so much the more considerable as we come

more and more into the sphere of the paralysed muscle's action. The same fact holds good in heterophoria, where, instead of paralysis, there is simply one or more muscles weakened so that they cannot properly maintain the balance that should normally exist in the struggle to overcome the action of opposing muscles.

In all cases of binocular diplopia the two images seen are not exactly alike. The eye that fixes its image sees it more distinctly than the other eye sees its image. This is obvi-

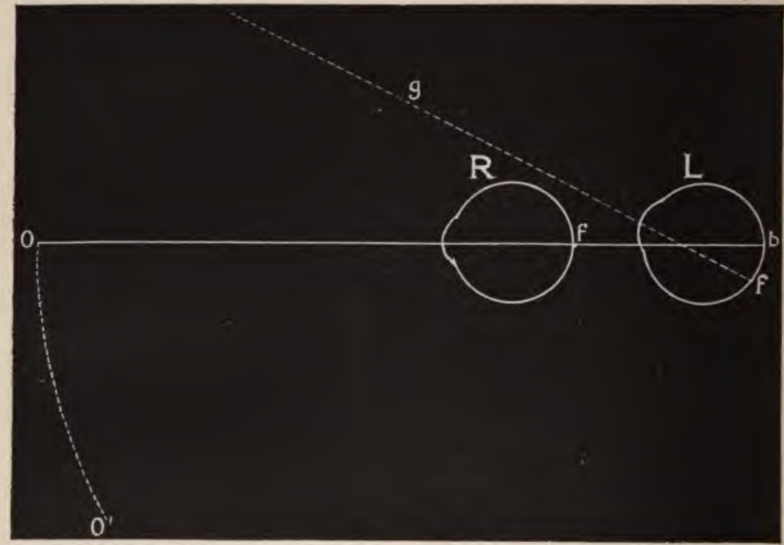

FIG. 39.—DOUBLE IMAGES WITH DIFFERENCE OF LEVEL (AFTER FUCHS).

ously the case; for, as we have seen, the one eye has its image on the macula and the other has not. The image should fall upon the fovea centralis retina at the centre of the macula lutea; but in the affected eye it may fall at a point some distance away, where vision is less distinct—in the perimacular, or even in the least distinct area of all, the peripheral region. It is for this reason that the name of true image is given to the one seen by the unaffected eye, and false image to the one falsely projected by the affected eye. Another reason why it is well called the false or the

apparent image is that the patient, reaching out to touch it, would simply reach out to one side of the actual object, as he sees it in the wrong place.

Another interesting point is the inclination of the false image. It is inclined in oblique vertical diplopia—that is, in all those cases where the deviated eye has undergone a movement of rotation round its antero-posterior axis, the result of a preponderating action of one of the obliques, or else one of the superior or inferior recti muscles. In Fig. 40

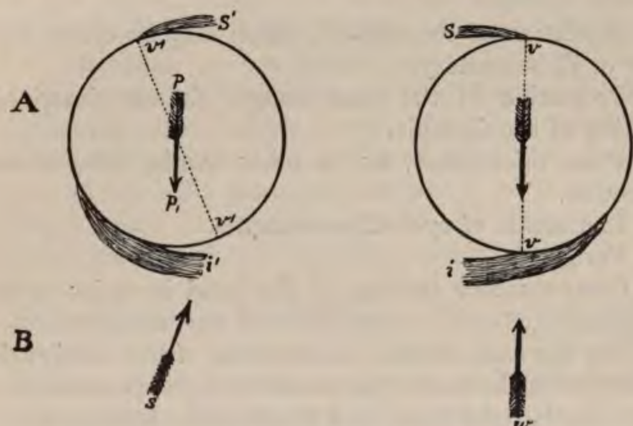

FIG. 40.—DOUBLE IMAGES WITH OBLIQUITY (AFTER FUCHS).

the left eye has undergone a movement of rotation which has inclined the vertical axis v^1v^1. It follows that an arrow held perpendicularly to the ground, and which in the right eye will form a perfectly vertical image, will form equally in the left eye a vertical image cutting the inclined axis, v^1v^1, as is indicated in the figure. It follows that the left eye sees the point p below and outside the vertical axis, and the point p^1 above and inside. The false image furnished by this eye is inclined, and this so much the more as the inclination of the vertical meridian is the more pronounced. Because the left eye is rotated round its sagittal axis (circumduction), there is obliquely false projection. The arrow is considered by this eye to have an oblique position, because it has been accustomed previously to con-

sider as vertical only objects whose images coincide with the vertical meridian. Thus, this phenomenon of diplopia is seen clearly to be of the greatest importance in the clinical study of all affections which concern the musculature of the eye. It is indispensable towards gaining a knowledge how to investigate the muscles, and we can by this one symptom derive valuable indications for an accurate and complete diagnosis.

Other general symptoms of ocular paralysis in association with the diplopia are :

1. Deviation of the eyeball, which may be either (*a*) primary or (*b*) secondary.

2. Projection of the false image, already described in speaking of the diplopia.

3. False orientation, or, in other words, false muscular projection.

4. Limitation of eyeball movements.

5. Vertigo.

6. Compensatory turning of the head in order to avoid diplopia.

7. For the same reason, the covering of the paralysed eye by the patient himself, who has learnt by experience that to do so affords relief from that troublesome symptom.

1. **Deviation of the Eyeball.**—Owing to the paralysis the deviating eye simply lags behind the other when the sound one fixes. This is what is meant by (*a*) primary deviation. It is often appreciable only when the eyes are turned in the direction of the paralysed muscle.

On the other hand, secondary deviation is somewhat different. It is the deviation which the sound eye undergoes when the affected one is made to fix. Unlike that of concomitant strabismus, in paralysis this secondary deviation is always greater than the primary deviation, and it depends on the amount of innervation or nervous energy sent into the associated muscle or muscles, which would make conjugate movements normally with those paralysed ones of the affected eye. This amount of nervous energy is always a great one, simply because it is that of the a[illegible] movement in the struggle against the paralysis of

the other eye. What is spent in vain against the paralysis in one eye sends the other to the extreme limit—the impulse, in fact, has its full effect in the direction of its would-be conjugate movement. Taking as an example paralysis of the external rectus of the right eye, the object being about 16 or 17 inches in front of the eye and slightly to the right side of it, the other eye being covered by a screen, the patient is told to quickly fix his eye on the object. Now change the screen to the affected eye while the patient is gazing at the object, the patient being told to still continue looking at the object, the sound eye then is seen to make a considerable outward excursion as the patient fixes the object again. This is evidence that the sound eye must have been turned in excessively while under cover. In other words, the internal rectus muscle of the left sound eye, the conjugate associate of the right (paralysed) external rectus, has been receiving excessive nervous energy all the time, while the uncovered paralysed eye has been struggling to fix the object.

2. **Projection of the False Image.**—This has been already described.

3. Closely allied to the foregoing is **False Muscular Projection** or **False Orientation.** It is a subjective symptom, and refers to the sense of the relative position of the eye and body generally to the objects in space. For instance, if a patient with the right external rectus paralysed shuts his left eye, and looks with his right eye alone at an object situated a little to the right hand—*i.e.*, within the sphere of action of the paralysed muscle—and then is told to point quickly with his finger at the object, we notice he always carries his finger to the right of the object that he points at, whence it follows that he mentally considers the object too far to the right (Von Graefe's reaching test). Remember that the other eye is covered, and he has fixed, as well as he can, the object, and yet his false projection continues simply because of his wrong mental habit of false orientation. Fuchs points out that the same phenomenon is shown by making a patient walk straight towards a given point with the help of his paralysed eye, the other being closed. " He

takes a wavering and zigzag course, first bending his steps too far to the right, then recognizing his mistake and correcting it ; then deviating anew to the right, and so on." When I was studying in the Paris eye hospitals, I paid a visit to the clinic of M. Landolt. He had an arrangement there for determining defective muscle sense or false subjective orientation, something on the same principle as the reaching test mentioned above. It consisted of a blackboard

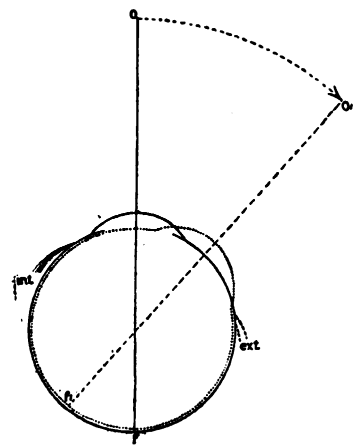

FIG. 41.—FALSE ORIENTATION IN PARALYSIS OF THE RIGHT EXTERNUS (AFTER FUCHS).

The object is falsely localized, because the patient is in error in regard to the position which his eye occupies. He feels as if his eye were in the position marked by the dotted line, and *o* is seen as if it were at o^1.

which had a white horizontal line immediately above another board that hung down in front of its lower half like the flap of a table. There was also a vertical line at right angles passing through the centre of the board, opposite to which was a place for the patient's chin when the flap was lifted up to the horizontal plane. The patient had to quickly touch the part of the vertical line below the flap while looking at the part of the line above the flap. Of course the flap prevented him seeing where his hand went, the other hand being held firmly to the side, and the eye not used being covered. The horizontal line on each side of

the vertical was marked with a scale, the figures being according to the angular deviation, like the smaller ones on the tangent scale of Maddox. (See Author's articles, "Medical Teaching of London and Paris," *The Medical Brief*, June, July, 1906.)

4. **Limitation of Movement of the Eyeball.**—This always is in the direction of the affected muscle. In complete paralysis movement is abolished, but it varies according to the degree of paresis, and may be so slight as to be only detectable by carefully determining the field of fixation. This can be done roughly by telling the patient to follow with his two eyes open, not moving his head, the tip of the observer's finger, or that of a pen or pencil carried in a systematic manner through the principal meridians. The observer compares the distances between the margins of the cornea and the canthi of the two eyes, and the edges of the lids in the upward and downward movements, so as to determine the ability or inability of the two eyes to follow in an equal degree. The relative positions of the corneal images of some distant object may also be used.

To precisely record the field of fixation a perimeter must be used. One eye being covered, the other one is directed to follow a small object moved along the arc. This is preferably a letter or some other object that can be clearly seen, so as to at once say what it is. The excursions of the eye under examination are in this way graphically recorded in all directions on a chart in the same manner as we record the field of vision (see Fig. 36).

For examples, we find that in paralysis of the inferior oblique muscle the field of fixation shows marked contraction above and to the outside, and in paralysis of the external rectus contraction markedly to the outside, etc. An instrument called a tropometer has been designed by Stevens in America for measuring in all directions the ocular movements. It consists of a telescope in which an aerial image of the cornea is formed near the eye-piece. For a more detailed description of this instrument the student may consult the standard American works on ophthalmology.

5. **Vertigo.**—This is chiefly the result of two of the other symptoms—viz., diplopia and false subjective orientation. It is designated visual or ocular vertigo, so as to distinguish it from auditory and other forms of giddiness. It occurs almost as much when the paralysed eye is alone performing the function of vision as when the two are uncovered and there is diplopia. Objects seem to move as the affected eye moves in the direction of the paralysed muscle. The patients become unsteady and timid, and often experience a feeling of nausea.

6. **The Patient turns his Head in a Compensatory Manner**; 7. **The Patient covers the Paralysed Eye.**—Both of these symptoms are for the purpose of avoiding the diplopia and the vertigo. They are both characteristic signs of ocular paralysis. A patient with comitant squint is not likely to cover up his squinting eye of his own accord, and the paralysis patient tells you that he does so to avoid the troublesome diplopia and the giddiness. The patient in walking about will either shut the one eye and keep it so, or, being unable to do that, will cover it with an eye-shade or a bandage. In regard to the oblique position of the head, this is the position nearly always at once assumed by the patient as soon as the shade or bandage is removed. He does this in order to bring the visual line of the affected eye to bear upon an object that is fixed by the sound eye; *i.e.*, he turns his head in the same direction as that of the defective movement. As an example of this, in paralysis of the internal rectus muscle of the right eye the head would be carried to the left. There is a definite position of the head for every variety of ocular paralysis—*i.e.*, of the extrinsic muscles. It diminishes the visual vertigo, and it is so characteristic of the paralysis that the skilled observer may from it alone suspect the nature of the affection.

The above symptoms characteristic of ocular paralysis are the more pronounced the more recent a case is, but in old cases they become more and more obscure, and hard to determine. (1) Patients learn by experience to avoid mistakes in orientation, and von Graefe's reaching test

ceases to be of the same diagnostic value. By experience the patient will learn that impulses of innervation for his paralysed eye correspond to much slighter actions than those for the sound eye, and by taking account of this fact he once more forms a correct judgment of the situation of objects. (2) After a time the diplopia disappears. This is due to the sensory perceptions of the paralysed eye becoming suppressed (exclusion). (3) Contracture of the antagonists of the paralysed muscle gradually takes place. For instance, in paralysis of the right externus it is the right internus that becomes contracted; and so, while in a recent paralysis of the externus the eye, when the gaze is directed straight forward, stands in the middle line, it afterwards becomes drawn in more and more, and can no longer be brought up to the median position. The result of this is an increase in the paralytic strabismus, this reaching a higher degree and becoming manifested over a more extensive area than before, insomuch that it exists not only upon the side of the paralysed muscle, but also over the entire field of fixation. Paralytic squint, because of this fact, comes to acquire a continuously greater and greater resemblance to the concomitant variety, rendering the distinction between the two sometimes extremely difficult. Duane believes many cases regarded as those of concomitant squint to have been paralytic in origin. Many cases of squint in children are due to the traumatism of instrumental delivery, and probably some of these at the outset were paralytic.

CHAPTER XII

INVESTIGATION AND SPECIAL SYMPTOMATOLOGY

THE facts that have been recorded in the two preceding chapters now place us in a position to study the special diagnosis of the one or more muscles affected, but before we can do so it is necessary that I should say a few words about the method of examination in investigating any given case. A patient complains of one or more of the general symptoms discussed in the last chapter, the most common being troublesome diplopia. He may be seen to have some divergence of one eye on moving the two eyes in one or other direction (strabismus paralyticus or luscitus). If the patient be a child, our first thought on seeing the case is that it is an ordinary case of squint (concomitant convergent strabismus), especially if there be no reason for suspecting a paralytic condition; but a differential diagnosis of the two conditions should be carefully made in every case. By means of the screen test one can at once find out whether the secondary deviation equals or is in excess of the primary (see Chapter VI.). If seen to be in excess it is undoubtedly a case of paralysis. In some cases mere inspection makes it easy to decide which muscle is paralysed and what eye is affected, but there are many other cases that need very careful investigation, and the examination chiefly depends upon determining the characteristics of the almost constant diplopia. The room should be darkened and the patient comfortably seated. First of all, by screening one eye we make sure that the diplopia is binocular; then the patient is told to look at a lighted candle at about

3 metres' distance. He sees two candles instead of one. We now place a ruby-red glass in front of one eye. Some surgeons also place a green glass in front of the other eye. Unless the green glass is used as well as the red, it is recommended not to use a trial frame, but that the patient should simply hold the red glass before one eye. The objection to a frame is that possibly it might give rise to false conditions by obstructing the vision in extreme excursions of the eye. My plan is to fix the ruby glass in the handle that is nearly always supplied with good trial cases. The examiner should stand in front of his patient, holding the candle at the required distance. At the examiner's back is the wall of the room, which is sufficiently large to prevent images of the light being projected on the side walls. In the clinic of Dr. Morax, at the Lariboisière Hospital, Paris, where I worked for some time, we had an excellent arrangement, consisting of an electric lantern, which showed a vertical streak of bright light; this was worked by pulleys from across the room, the result being recorded on one of the nine squares, as shown in the diagrams at the latter part of this chapter—three squares for recording diplopia in the upper field, three for the horizontal field, and three for that in the lower field. In order to render the diplopia manifest a prism has to be used in some cases, so as to bring the false image upon a sensitive part of the retina away from the extreme periphery; or it may even have to be brought away from the blind spot of the optic papilla. It is useful to record on a blackboard what the patient tells you he sees, a red chalk being used for the image belonging to the eye that has the red glass, and a white chalk for the image of the other eye. It is best to put the red glass in front of the eye that is presumably the affected one, but in order to make sure it is sometimes necessary to change from one eye to the other, making the true image red instead of white. Occasionally a prism is of service in those cases where two or more muscles are affected for eliminating the paralysis of one of them in order that the effects of paralysis of the remaining ones may be more easily studied.

General Principles.—Certain general principles must be borne in mind.

1. In the first place, it is clear that each muscle having a principal action of its own and subsidiary actions also in the case of all except two, we are bound to find that any failure of a muscle will become most apparent in its chief line of action. Our first and most important rule may be therefore stated as follows: *The false image has the position as well as the inclination that the normal action of the affected muscle would give to the eyeball.* For instance, supposing a muscle's chief function to be that of moving the cornea downwards, if paralysed, on the patient attempting to look downwards diplopia becomes manifest or the more manifest; and, further, if the function of that muscle is best exercised in one or other of the lateral movements, according to which of the two possible muscles, it may be—for example, adduction (*i.e.*, looking inwards), in the case of the rectus muscle—it will be in that attitude that the diplopia will be the most obvious; there the images will be farther apart.

It is an impossibility for the function of a muscle to be taken up and discharged accurately by another muscle, or even by a combination of muscles. In abduction, for instance, there certainly is the combined action of the two oblique muscles, which is accessory to that of the external rectus; but supposing the latter to be paralysed, these two obliques could never take up accurately its rôle, and this is a fact, without exception, as regards the action of all the muscles, not only of the eye, but of the whole body. If a muscle be paralysed, its fellows are unable to hide the fact. Bearing this in mind, we can see clearly that in the direction in which a muscle normally has its greatest efficacy, there failure to act comes to be the most evident. We should not, however, imagine that double vision cannot be demonstrated in any other direction, although, generally speaking, the patient is not conscious of it until he has received the knowledge that his eye's position is also faulty in this other direction through it having been by proper means demonstrated.

Returning to our example of paralysis of the external

rectus, the patient, we find, only complains of diplopia on looking outwards; but supposing we put a vertical prism in front of one eye sufficiently strong to deprive him of any power of fusing images near together, separating them vertically, then lateral separation of the images is evident to him over the whole field of his vision.

The above rule also has been clearly stated in another way by Dr. Sym of Edinburgh as follows: "Double vision is to be found in one or other of the great directions—upwards, downwards, to the right, or to the left of the patient—and the muscle paralysed is one of those whose function it is to move the eye in that direction."

2. The question, Which is the false image? is answered by our next rule: *The false is always that image which is farthest in the direction in which double vision exists.* As the candle is moved farther and farther in the direction where we find double vision existing, the separation between the two images becomes wider and wider. This is due to the fact that the paralysed muscle's inability to meet the call upon it becomes more and more obvious. The distance of the two images from each other varies according to the greatness of the angle subtended both in homonymous and in crossed diplopia.

With a red glass before one eye, knowing which is the false image, we also know which is the affected eye; because, supposing the glass to be before the sound eye, the false image would belong to its fellow, and be therefore white, and *vice versa; i.e.*, supposing the red glass to be before the affected eye, the false image would be red and the true image white.

3. Our next and last rule answers the question, Which muscle of an affected eye is the one paralysed? It is as follows: *The false image is deviated exactly in the direction of action of the paralysed muscle.* If the direction of a muscle's action is to the left, the false image is on the left. If the muscle paralysed in health would have elevated the cornea, the false image will be higher than the true one; on the other hand, if the direction of action is to depress the cornea, as in looking downwards, the false image will be below the true one, and so on. An ophthalmic surgeon

who frequently has opportunities for employing these tests with the red glass is able to deduce accurate results from the leaning of the images; but care needs to be taken that a patient does not mislead the examiner by faulty observations and wrong methods of expression.

Some surgeons have the candle a fixture, and tell the patient to move his head in one or other of the required directions—upwards, downwards, to the left, or to the right—while keeping both eyes fixed on the light. This answers as well as the other method if due care is taken, and is of advantage where room space presents a difficulty.

By remembering that abductor muscles, if paralysed, have homonymous diplopia and adductor ones have crossed, we may tell at once which of two elevator or depressor muscles is the affected one; therefore it is only for the purpose of making doubly sure that we need worry concerning circumductory movements. These latter may be studied by observing that, should the upper end of a false image be leaning to the right, the muscle paralysed has the function of rotating the eyeball round a sagittal axis, so that the upper part of the cornea is rotated to the right. In a similar manner, should the upper end of the false image be leaning over to the left, the muscle affected rotates the upper part of the cornea over to the left. The following schema by Guende is taken from the little book of M. Lagrange, written for Paris University students, entitled " Précis d'Ophtalmologie."

Abductor Muscles.—Homonymous diplopia (false image shown by the slight shading).

The separation of the images increases on the side of the paralysed eye.

Adductor Muscles.—Crossed diplopia (false image is white in the schema).

The separation of the images increases on the side of the sound eye—*i.e.*, also the side of the affected muscle.

1. The false image diverges from the true at its upper end. The inclination is—

Inwards = superior rectus.
Outwards = inferior rectus.

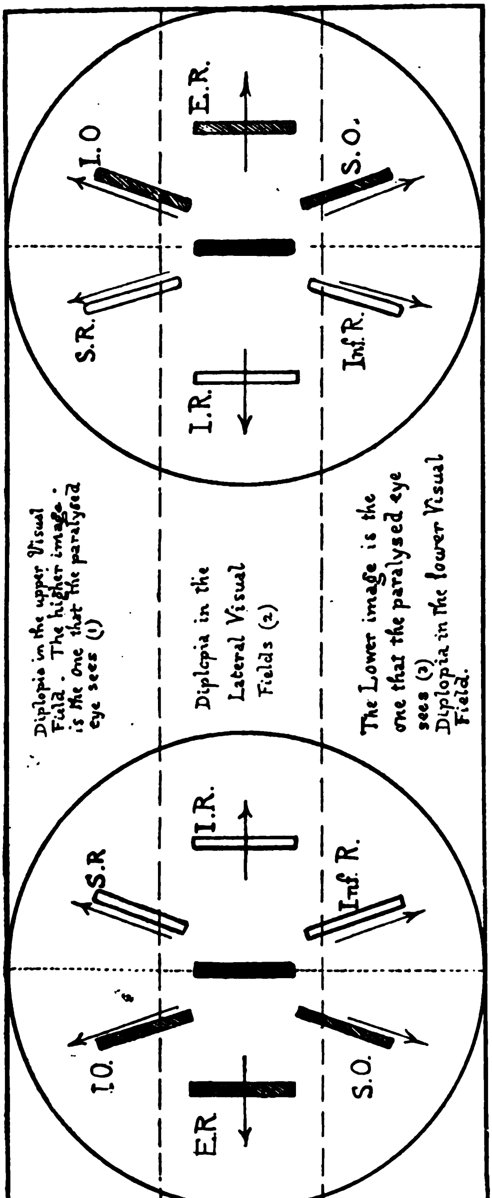

FIG. 42.—SCHEMA (AFTER GUENDE).

2. Internal and external recti muscles. Merely lateral separation of images. They remain parallel and at the same level (horizontal diplopia).

3. The false image diverges from the true at its lower end. The inclination at its upper end is as follows:

Inclined outwards = inferior rectus.
Inclined inwards = superior oblique.

It may be criticized as repetition giving the above schema, and then to state the same facts later in dealing with each muscle separately; but such repetition is excusable, as it more thoroughly fixes a clear idea of the subject upon the mind.

The false image is always less distinct than the true one, as its position is on a more peripheral portion of the retina.

The false image, being less distinct, seems farther away except when it is in the lower half of the visual field; if fairly clear, it appears nearer, the explanation for this apparent nearness being that it is projected seemingly on a horizontal surface, which seems to the patient to bring it closer.

Paralyses of Muscles considered Separately.

Taking each muscle separately, and in each case considering, for the sake of simplicity, an isolated paralysis, we will record our results on one of the nine squares already mentioned, the whole of which together represents the wall of a room in front of which our candle is moved.

Paralysis producing Homonymous Diplopia.

First of all, we will take the three abductor muscles, paralysis of which produces homonymous diplopia.

Superior Oblique Muscle.—We observe an upward squint, which is slightly convergent, with outward circumduction. There is also a characteristic position of the head, the

face being inclined downwards and towards the healthy side.

The diplopia is homonymous, and occurs only in the lower part of the visual field.

As the eye is abducted, lateral separation of the image increases ; the obliquity of the false image also increases. As the eye is depressed and adducted, the vertical separation of the images increases. As a rule, as explained above, the image of the affected eye seems the nearer of the two ; the line of demarcation between the images is slightly oblique to the horizontal (oblique vertical diplopia). We have in the diagram (Fig. 43) recorded the two results of two different cases ; one case being that of right superior oblique paralysis, the other being a case where the left superior oblique muscle is paralysed. (N.B.—In Figs. 43 to 48 paralysis of both left and right sides are represented to obviate the necessity of twelve figures instead of six.)

Inferior Oblique Muscle.—The patient experiences diplopia on looking upwards ; it is homonymous (Fig. 44). Like the preceding, the lateral separation of images increases as the eye is abducted ; the obliquity also increases with abduction. The vertical distance between the images increases as the eye is elevated and adducted. There is a downward slightly convergent squint, and the rotation of the eyeball is inwards. The face is directed upwards and slightly towards the sound side. The restricted movement is upwards and outwards. The line of demarcation between the true and false images is inclined to the horizontal, the diplopia extending lower towards the affected side.

External Rectus Muscle.—There is limitation in the outward movement of the eye. In complete paralysis the eye can only be turned but little beyond the median line ; while in incomplete it may often go to nearly the normal limit, but with an irregular jerking motion. The head is turned towards the paralysed side. The squint is internal (convergent). Diplopia appears in looking towards the paralysed side (homonymous). The double images are on the same level, and are parallel (Fig. 45). Their lateral separation increases as the paralysed eye is abducted. The line which separates

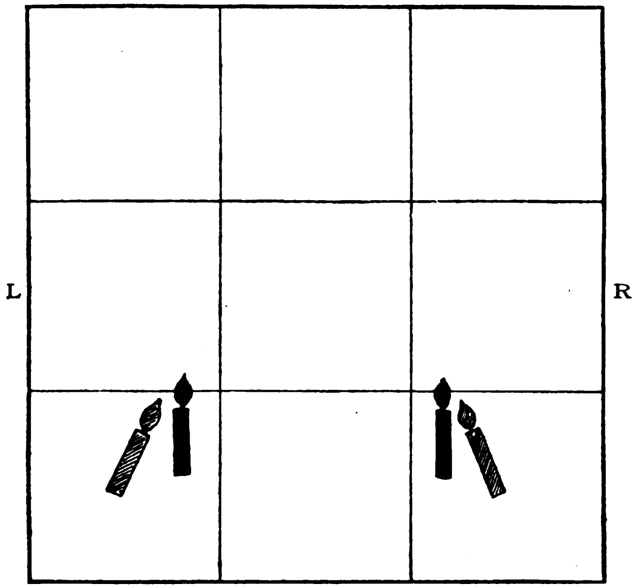

FIG. 43.—SUPERIOR OBLIQUES.

L, Left superior oblique (homonymous diplopia); R, right superior oblique (homonymous diplopia).

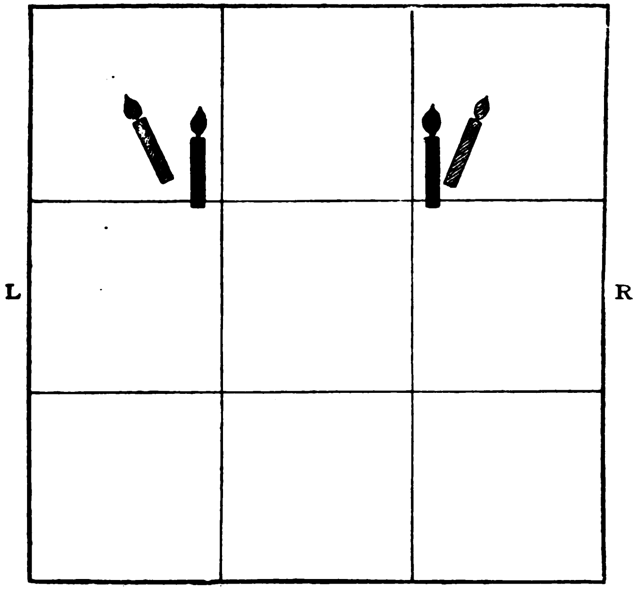

FIG. 44.—INFERIOR OBLIQUES.

L, Left inferior oblique (homonymous diplopia); R, right inferior oblique (homonymous diplopia).

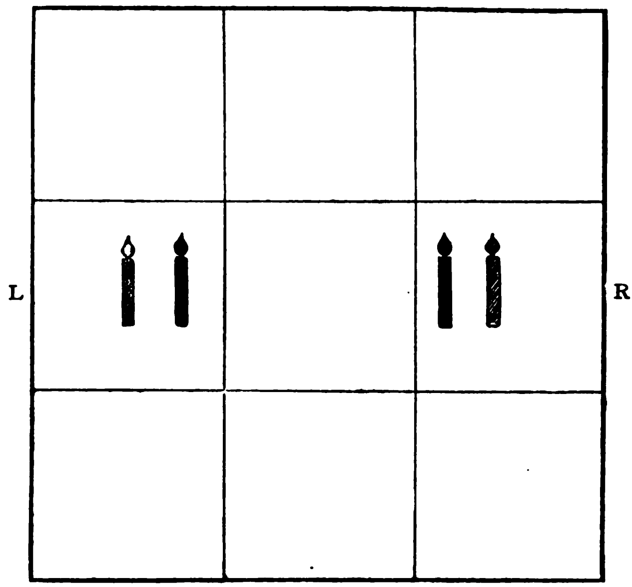

FIG. 45.—LEFT AND RIGHT EXTERNAL RECTI.

L, Left external rectus (homonymous diplopia); R, right external rectus (homonymous diplopia).

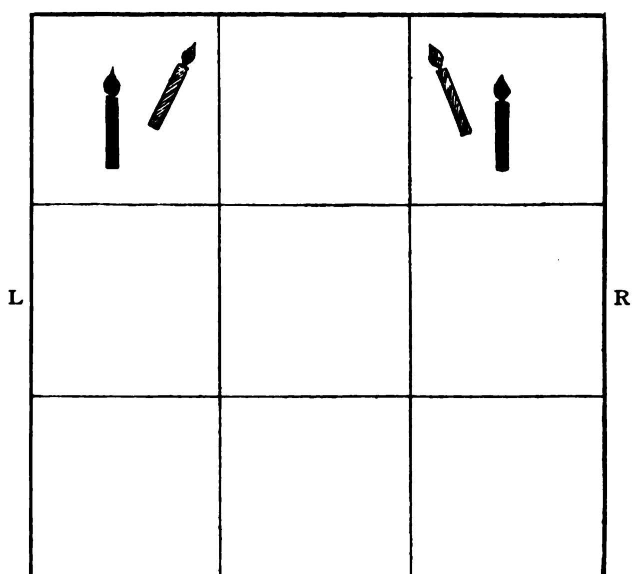

FIG. 46.—LEFT AND RIGHT SUPERIOR RECTI.

L, Left superior rectus (crossed diplopia); R, right superior rectus (crossed diplopia).

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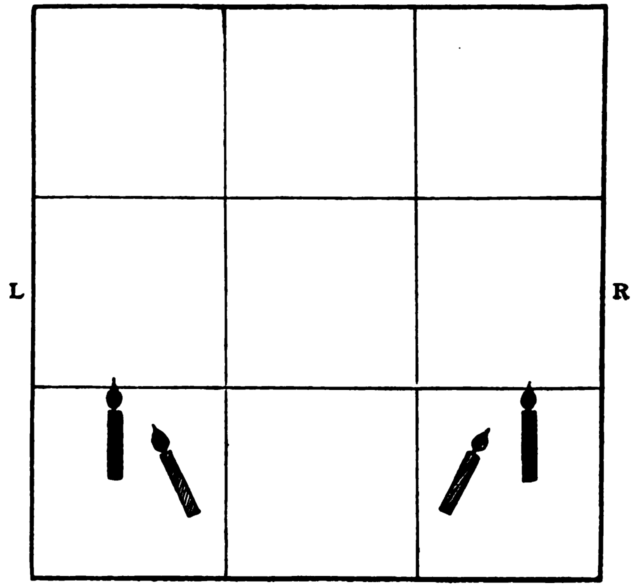


FIG. 47.—LEFT AND RIGHT INFERIOR RECTI MUSCLES.
L, Left inferior rectus (crossed diplopia); R, right inferior rectus (crossed diplopia).

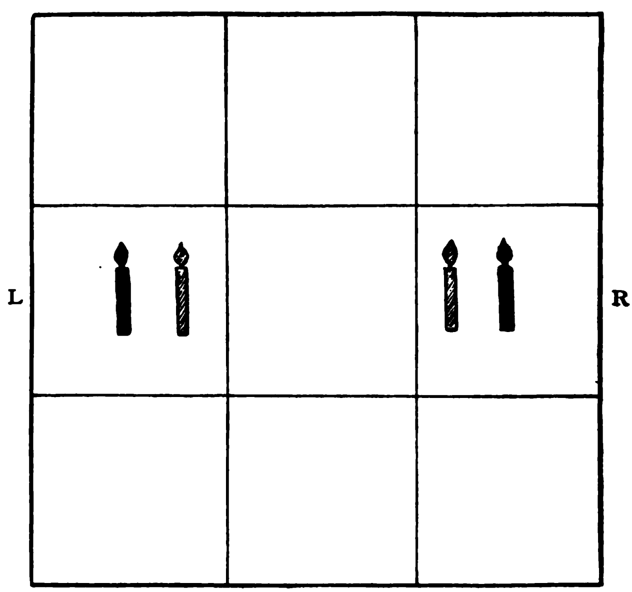


FIG. 48.—LEFT AND RIGHT INTERNAL RECTI MUSCLES.
L, Left internal rectus (crossed diplopia); R, right internal rectus (crossed diplopia).

that part of the field in which there is single vision from that in which it is double is almost, but not quite, vertical. It is inclined a little obliquely, because the diplopia extends farther towards the healthy side below than above.

Paralysis producing Crossed Diplopia.

Superior Rectus Muscle.—There is a downward squint, and the deviation on looking up is rather downwards and outwards. The restricted motion is upwards and slightly inwards. The diplopia is on looking up, and it is slightly crossed (Fig. 46). The false image is higher than the true; its upper end is inclined to the healthy side. The difference in height between the two images increases on looking upwards, and the obliquity increases on looking to the healthy side—*i.e.*, it increases in adduction. The line of demarcation is inclined to the horizontal, the diplopia extending lower towards the affected side. The face is directed slightly upwards.

Inferior Rectus.—The restricted motion is downward. The squint is upwards and rather outwards. The diplopia is on looking down, and is slightly crossed (Fig. 47). The obliquity of the false image increases in adduction. The lateral separation increases progressively as the eyes are adducted. The false images are lower and inclined towards the healthy side—*i.e.*, the side of adduction. The line of demarcation is inclined to the horizontal, the diplopia extending lower towards the affected side. The face is directed slightly upwards.

Internal Rectus.—The restricted motion is inwards; the affected eye deviates outwards; the diplopia is on looking towards the sound side—*i.e.*, it is markedly crossed (heteronymous). The images are parallel and of the same height (Fig. 48). The distance between them increases on looking towards the healthy side and on looking upwards. The line of demarcation between the true and false images is oblique to the vertical, the diplopia extending farther towards the healthy side above than below. The face is turned in the direction of the affected eye.

Complete Paralysis of the Third Nerve.—Ptosis is a marked symptom. There is slight exophthalmos. Accommodation is paralysed, and there is some dilatation of the pupil. The movements are everywhere restricted except outwards. There is crossed diplopia, the false image being oblique and inclined towards the sound side. It also appears higher than the true image, and nearer to the patient. The distance between the images increases on looking towards the sound side, and the difference in height increases on looking upwards. The face is inclined slightly upwards and towards the sound side.

CHAPTER XIII

ETIOLOGY, PROGNOSIS, AND TREATMENT

In deciding whether a case of squint is of the paralytic or of the functional (concomitant) variety, the following points should be taken into consideration :

1. **Age of the Patient.**—Paralysis may occur at any age, whereas we have seen that the functional strabismus occurs in young children under six years if convergent, and in older children if divergent—commonly the result of myopia.

2. **The Presence or Absence of Diplopia.**—In the vast majority of paralysis cases diplopia is present, although, as we have pointed out, there are a few cases where it may possibly be absent. In functional squint it is nearly always absent.

3. **The Onset of the Squint.**—Squint in paralysis is almost always of sudden, or at least of rapid, onset. Concomitant or functional squint, as a rule, comes on rather gradually, making its first appearance as an occasional deviation—a period, in fact, of ocular indecision. This may be for months before a decided squint becomes established.

4. **The Primary Deviation.**—In paralysis the error in position is greatest in certain movements of the eyes. In strabismus the faulty position of the deviating eye is the same all over the field of fixation.

5. **The Secondary Deviation.**—This differs from that of strabismus by being much greater than that of the primary. In strabismus cases, as we have already mentioned, the two deviations are equal.

6. **Projection.**—In paralytic squint the projection of the

deviating eye is erroneous. Such is not the case in concomitant strabismus, where projection is always correct.

7. **Irregularity of Motion** is a very characteristic indication of paralysis.

In any given case, when the muscle paralysed has been discovered, we should remember that only the first step has been made towards a proper diagnosis. The lesion has to be determined, its position, its precise nature, and its underlying cause. It is only when all this has been accomplished that we may consider we have arrived at a satisfactory and complete knowledge of our case.

Considered clinically, the causes of ocular paralysis may be divided into two main classes: (1) central; (2) peripheral.

These, again, are subdivided as follows:

1. Central— (*a*) Cerebral (between cortex and nuclei).
   (*b*) Nuclear.
   (*c*) Fascicular.
2. Peripheral—(*d*) Basal.
   (*e*) Orbital.

Central Causes of Paralysis.

(*a*) **Cerebral Lesions.**—Above the nuclei the nerve impulses are to movements of the eyeball as a whole, rather than to those of individual muscles. Lesions produce conjugate or associated deviations. Stimulation of the right hemisphere causes deviation of the eyes to the left, and of the left hemisphere deviation to the right. A lesion, therefore, that would act destructively in or near the cortex would paralyse this movement on one or other side, and the eyes would be turned by the action of the opposing conjugate muscles away from the muscles that are conjugately paralysed. This condition frequently accompanies hemiplegia. The eyes are, therefore, turned towards the lesion. Irritative lesions, of course, have the opposite effect—*i.e.*, the eyes are turned towards the convulsed side; also, in a

destructive pontine lesion the eyes would be towards the paralysed side. These cases have little to do with the ophthalmic surgeon ; they belong rather to the domain of general medicine.

(*b*) **Nuclear Lesions.**—The nerve centres upon the floor of the fourth ventricle are affected. The sixth nerve has its deep origin here, and would therefore be involved, producing paralysis of the external rectus. Close to the fourth ventricle in the aqueduct of Sylvius we have the nuclei of origin of the third and fourth nerves, and these will be nearly always involved in any large destructive lesion in this situation. This consequently gives us the condition known as ophthalmoplegia, or total paralysis of the eye muscles. In lesions of the sixth nucleus the facial nerve is very likely to suffer, the two nuclei being so close to each other. It is characteristic of nuclear paralysis also to have the intrinsic muscles affected (ophthalmoplegia interna), although we may have the whole third nerve paralysed with the exception of the two interior muscles (ophthalmoplegia externa), and this is said to be equally characteristic. Occasionally, an isolated paralysis of a single muscle supplied by the third is of nuclear origin. These conditions will be dealt with more in detail in the following chapter. In the aqueduct of Sylvius the convergence centre is believed to be situated. Paralysis of convergence occurs sometimes by a lesion here ; it is generally a symptom of disseminated sclerosis. This paralysis must not be confounded with the insufficiency of convergence that occurs in cases of high myopia. Nuclear pontine lesions are said to give rise to conjugate lateral paralysis.

(*c*) **Fascicular Paralyses.**—These are often impossible to differentiate from those due to lesions of the nuclei and of the base. There is frequently hemiplegia on the opposite side. In rare cases a lesion of the crura cerebelli will cause upward deviation of one eye and downward deviation of the other.

Peripheral Causes of Paralysis.

Basal lesions are the most frequent of all causes of ocular paralysis. The causes due to basal lesions are of three kinds :

(*a*) Inflammation (meningitis) involving the nerve trunks.

(*b*) Pressure from a tumour, or directly by vascular distension, and also indirectly from enlargement of the ventricles. Abscess in the brain substance also causes paralysis in this way.

(*c*) Disease or injury of the nerve trunks themselves. The injury may be due to a fracture of the base of the skull.

An orbital paralysis is usually due to an injury—the pressure of a tumour or an aneurism, the presence of a foreign body in the orbit, periostitis at the apex of the orbit, fracture at the sphenoidal foramen. There may be also partial or complete congenital absence of a muscle, and lastly, but not unfrequently, it may be due to those peripheral lesions exemplified by the action of syphilis, rheumatism, diphtheria, and " cold."

A paralysis that picks out a single muscle from a group all supplied by one nerve (the third) is much more likely to be orbital than basal.

The presence or absence of such symptoms as headache, facial paralysis, hemiplegia, etc., are of great assistance in the differential diagnosis of these lesions.

The long-exposed course of the sixth nerve along the base of the skull renders it peculiarly liable to injury, especially in fracture, involvement in neighbouring inflammatory processes, etc. A progressive paralysis of all the muscles of one eye might either be orbital, basal, or nuclear. If it were orbital, one would expect to find some other evidence of tumour, aneurism, or whatever might be the lesion causing it locally. The optic nerve would soon become affected. The paralysis would be progressive, because due to a progressive lesion, which would spread laterally and involve other structures. In cases where it was nuclear the nuclei of the opposite side would soon become involved. Hemianopsia would occur, and even hemianæsthesia, from fibres of the optic tract on the same side becoming involved.

Charcot has given the name "ophthalmic migraine" to a peculiar affection he describes of the third nerve. It is accompanied by hemicrania on the same side. Paralysis as a rule attacks the whole nerve, but each attack is not of long duration, only that it will recur again and again. It may occur in men, but it more frequently occurs in women, with whom it seems intimately related to their menstrual function.

Congenital paralysis of one or both of the sixth nerves is another peculiar and interesting condition that is occasionally met with.

Underlying Causes of the Various Lesions.—Syphilis, either directly or indirectly, accounts for by far the larger number of cases. Some are due to the presence of gummata, some to syphilitic disease of bloodvessels, and some are the result of locomotor ataxy, this latter undoubtedly being a syphilitic disease manifestation. A few cases also occur from time to time in which the muscles are paralysed as the direct manifestation of syphilis. One or more of the ocular muscles may be paralysed as the first premonition of sclerosis of the spinal cord. When both eyes are affected the lesion is intracranial and generally basilar.

Tubercle also accounts for quite a number of cases. There is either in these cases direct disease of the nuclei, or the paralysis may be due to tubercular meningitis, and also to the pressure of tubercular nodules. Other causes are diphtheria, rheumatism, diabetes, and trauma. Bright's disease is said to be indirectly responsible for some cases, and others are attributed to "cold."

Diabetes and diphtheria are alike in this respect, that the toxin of each is able to cause paralysis of accommodation (nuclear paralysis), and in the course of either inflammatory complications may cause direct paralysis of peripheral nerves. Strangely enough, the inferior oblique muscle is never paralysed by itself, except it be as a result of trauma, this latter arising through some damage—by a blow or by a penetrating wound—to the floor of the orbit. The cases, not infrequently recurrent, that are attributed to rheumatism and to cold especially affect the external rectus.

Prognosis of Ocular Paralysis.—The most favourable in the peripheral forms. A great deal depends upon the question whether the lesion is or is not syphilitic; if it be, the prognosis is good. Recovery is the rule, but the process is very slow in many cases. It may happen that, after steadily persevering in our treatment for a long time with apparent lack of success, one sees a paralysis quickly pass away; and this may happen whether it be produced by a nuclear lesion, or by a gumma at the base, or an orbital affection.

A sudden onset of the paralysis means, as a rule, that there will be recovery after a time, or the case will settle into a perfectly stationary condition.

Nuclear paralysis occurring in diabetes is said to be of grave import, but authors do not all hold this view.

Treatment.—This, of course, varies according to the nature of the cause, which should always receive due consideration in our selection of a remedy. Internal medication is of the greatest importance. In a rheumatic patient antirheumatic medicines should be employed; in a syphilitic antisyphilitic remedies, such as mercury and iodide of potassium.

A method of treatment for this latter class of cases much in vogue in Paris is the intramuscular injection of mercurial oil. At the Lariboisière Hospital the injections were given about once a week, or once every ten days, the dose being about a cubic centimetre of *huile grise* (grey oil). The formula is as follows:

℞ Hydrargyri metallici	..	2 grammes
Lanolini	..	2 ,,
Olei olivi sterilisi ..	..	6 ,,

Sig.: An injection of a cubic centimetre every eight days.

The injections are made into the thick part of the buttock, with strict aseptic precautions.

Barthelemy's syringe is used. The needles are made of platino-iridium, so that they are unaffected by the mercury.

Another good formula is that of Lafay. It is as follows:

℞ Purified mercury	40	grammes
Lanoline, anhydrous, sterilized	12	,,
White vaseline, sterilized ..	13	,,
Medicinal vaseline oil	35	,,

This contains 40 per cent. of mercury by weight. About 8 centigrammes are used as a dose. Of course, during the treatment no other mercurial remedy is administered, either by the mouth or by inunction. The patients are weighed before the treatment, and their urine is examined. Those suffering with albuminuria or scrofula are treated with smaller doses at longer intervals, or other methods of treatment adopted. Hot baths, three times a week at bed-time, assist the treatment. Care is taken with regard to the teeth, and an efficient mouth-wash ordered to be frequently used. The method of injection is as follows: After cleansing the skin of the buttock with a little methylated spirit, or 1 in 40 carbolic lotion, plunge the needle quickly into the gluteal muscles. To make sure that you have not penetrated a vessel exhaust your needle with an empty hypodermic syringe. Should you draw blood, it is necessary to remove the needle and make another plunge; then inject your grey oil, and massage the part for two or three minutes. (Those who desire further information should refer to Lambkin's work on "Syphilis," published by Baillière, Tindall and Cox, London.) As regards medicines by the mouth, small doses of grey powder, large doses of iodide, and the yellow iodide of mercury in small doses may be administered. For the post-diphtheritic paresis small doses of the tincture of gelsemium. This is a good remedy in all cases of ocular paralysis, especially when the external rectus is affected. Strychnine and nux vomica are useful remedies, the latter especially, where the stomach has been deranged by the abuse of tobacco and alcohol. The strychnine may be given hypodermically. If by the mouth, in increasing doses, so that they approach to what may be termed heroic. Locally, blisters are recommended over the temple, but the period of their probable benefit is

but short. The method, recommended by Dr. Sym of Edinburgh, is to apply the blister over a very small area of the temple, and to repeat it over a neighbouring portion of skin two or three times, at intervals of forty-eight hours. "Blistering has fallen, apparently, into disrepute; not because it is ineffective, for in truth" (says Dr. Sym) "it is of great service, but chiefly, as it seems to the writer, because pathologists find difficulty in explaining the mode in which it acts. It has the misfortune to be, or to look as if it were, at variance with accepted theories, and therefore practitioners are apt to look askance at it." Although Sym states that he cannot recommend electricity, this is said by other authors to be a most valuable agent for the cure of ocular paralysis. The constant current should be used—not more than 2 or 3 milliampères. The application should be made daily, for from three to five minutes at each sitting, with the negative pole over the insertion of the muscle and the positive pole at the occiput. Forcible movements over the eye in the line of action of the muscle involved has been recommended. This is done as follows: The eye having been anæsthetized with cocaine, the conjunctiva is seized with fixation forceps over the insertion of the paralysed muscle, and the eye is strongly turned in the direction of action of the weakened muscle, and then in the directly opposite direction. The idea is to assist the muscle to recover tone. As a last resource, careful tenotomy of the opposing muscle, with or without advancement, may be undertaken. The advancement should be made according to the degree of divergence. This should only be done after all hopes of improvement by other means are at an end. Spectacles with a ground glass before the paralysed eye may be employed, the patient thus being saved the annoyance arising from his diplopia and false orientation. Maddox and others have recommended the use of prisms. If these are prescribed—and they certainly give great relief in some cases—it is best always to divide the effect between the two eyes. For instance, in a case that requires a prism of 8 degrees apex upwards, to unite the images it is better for the patient to wear before each eye a prism of 4 degrees on

one side apex upwards, and on the other side apex downwards. The great objection to this practice is that even weak prisms are rather heavy, and therefore inconvenient to wear, so that they are not often prescribed. Should they be employed, care must be taken that the defect is not quite corrected, as it is good practice to encourage the enfeebled muscle to efforts at recovery by leaving still a slight separation of the images, which may be overcome when the desire for fusion urges the weak muscle to contract. If full correction be worn there exists no incentive to action on the part of the enfeebled muscle.

CHAPTER XIV

OPHTHALMOPLEGIA, PARALYTIC MYDRIASIS AND MIOSIS, NYSTAGMUS, ETC.

IN order that I should do ophthalmoplegia justice I purpc devoting the first part of this chapter to its consideratic and then finish the subject of ocular paralysis with a f(remarks concerning paralytic mydriasis, miosis, etc. T. subject of nystagmus may also be conveniently consider at the latter part of this chapter.

Ophthalmoplegia is of nuclear origin, the lesion bei situated in the floor of the fourth ventricle, or in tl aqueduct of Sylvius, close to that region. The term impli a paralysis of the ocular muscles due to a lesion situated their nuclei of origin. The principal nerve paralysed the third or motor oculi nerve. Sauvineau states that least two muscles supplied by the third and one oth nerve besides should be paralysed.

The three chief clinical varieties are—

1. Ophthalmoplegia externa ;
2. Ophthalmoplegia interna ;
3. Ophthalmoplegia totalis.

The first is the most frequent ; in this the two intrinsi muscles escape. On the other hand, in the second variet only the pupil and the muscle of accommodation ar involved. In the third, as its name implies, there is com plete paralysis of all the eye muscles, except, perhaps, th external rectus. The lids droop, the eye is directed for wards or strongly outwards, it is quite immovable, th

pupil is dilated, and there is no power of accommodation. A slight degree of exophthalmos is noticed because the recti muscles have lost their tone.

Ophthalmoplegia may be congenital or acquired. There is a very rare infantile variety that is acquired, but nearly all the acquired cases occur in adult life.

The acquired forms are under two heads—(*a*) acute and (*b*) chronic.

It sometimes happens that there is a more or less complete paralysis of the levator palpebræ superioris, giving rise to ptosis, but it frequently happens that the branch of the third supplying this muscle escapes. Congenital ptosis is not, as a rule, included under the term "ophthalmoplegia," although of nuclear origin. It is a partial paralysis affecting only the third nerve.

The terms "complete" and "incomplete" ophthalmoplegia are used to specify whether all or only some of the muscles are affected. The disease is nearly always double. When one eye only is affected, it is termed "monocular ophthalmoplegia." The total variety, because both intrinsic and extrinsic muscles are paralysed, is often called "mixed ophthalmoplegia." The eyes have a strange fixed look, which is especially striking in the complete cases. Occasionally there is some paresis of the facial nerve, and the muscles near the eye, notably the orbicularis palpebrarum, may be paralysed, so that there is difficulty in shutting the eye, and the cornea may suffer as a consequence. This is due to the nucleus of the seventh nerve becoming involved. Ptosis is of more frequent occurrence in the infantile cases than in those ophthalmoplegias that occur in adult life, but the disease in any case is rare in children. Sometimes the disease is steadily progressive, the other cranial nerves becoming involved; in other cases, after a certain number of muscles have become involved, the disease becomes stationary. Mental impairment is not at all uncommon. The disease occurs as an entity, but it may also complicate other nervous affections.

Acute Ophthalmoplegia.—This form of the disease is a rare condition. It is nearly always associated with chronic

alcoholism, although there have been one or two cases recorded where it has seemed to have been due to other toxic conditions. The onset is sudden; there is severe cerebral disturbance, headache, vomiting, delirium, and stupor. Optic neuritis is seen on inspecting the discs. The disease spreads quickly to the bulbar nuclei, and death ensues in about ten days or a fortnight. On post-mortem examination hæmorrhages are found in or near the nuclei. Perhaps nothing much can be seen, and the only inference then is that there has been severe toxæmic poisoning, specially affecting these nerve centres. Subacute cases of nuclear paralysis, not complicated by bulbar lesions, occur more frequently, in which the prognosis is not nearly so grave.

Chronic Ophthalmoplegia.—This is the more common form of the disease. It is generally due to syphilitic arteritis. It may, however, occur as a complication of tabes dorsalis, disseminated sclerosis, multiple neuritis, exophthalmic goitre, and general paralysis of the insane. Sometimes it supervenes after diphtheria, and it may even come on, in exceedingly rare cases, after measles, scarlet fever, and influenza. It occurs, like the acute form, from toxæmic poisoning, such as alcohol, lead, nicotine, carbon dioxide, ptomaines, etc. Traumatism may give rise to it. It is usually progressive and bilateral. The prognosis is unfavourable in the extreme.

Pathology.—According to Gowers, the usual changes in chronic ophthalmoplegia are of a degenerative and atrophic nature in the nuclei affected. Gowers lays special stress upon the frequency of syphilis as an element in these degenerative diseases.

Diagnosis.—The chief points are: the bilateral occurrence of the paralysis; the muscles are paralysed in a symmetrical manner; the rarity of ptosis; the paralysis of nearly all the ocular muscles supplied by the third nerve except the intrinsic ones, and *vice versa.* Complete paralysis may be due to an injury at the base of the brain, in which the nerve nuclei are not affected.

Treatment.—If the cause of the trouble can be discovered, treatment should be directed to that. Where a distinct

syphilitic origin is found, vigorous treatment with mercury and with the iodides should be practised. The treatment by intramuscular injections of mercurial oil, as described in the last chapter, might be tried in these cases. Hypodermic injections of strychnine may benefit. Arsenic in some cases is useful as a tonic and nerve stimulant. Electrical treatment also, as described in the previous chapter, may be of service. An opaque glass in a spectacle-frame will be of use in counteracting the annoying diplopia. Prisms are of no use in these cases, because those which fuse the images are generally too heavy for spectacle-frames. In slight cases of long standing operative treatment may be indicated.

Paralytic Mydriasis.—Paralysis of the iris associated with paralysis of the ciliary muscle is known as ophthalmoplegia interna, but a paralysis of the iris by itself sometimes occurs as the result of lesions affecting the nucleus of the third nerve or of the nerve itself. The pupil is partly dilated, and is susceptible of further dilatation by the instillation of a mydriatic. The chief causes of this condition are to be found in brain affections, especially general paralysis of the insane, lesions at the base of the brain, and those involving the nucleus, thrombosis of the cavernous sinus, tabes dorsalis resulting in third nerve paralysis, orbital disease pressing on the ciliary nerves, increased intraocular pressure (intraocular growths and glaucoma), blow received upon the eyeball, diphtheritic and ptomaine poisoning, apoplectic coma, syphilis, and mydriatics used internally and locally. That form of mydriasis which occurs in optic atrophy is not a true ocular paralysis. It results from the interruption in the transmission of light impulses from the retina.

Paralytic Myosis is usually met with as a symptom of tabes dorsalis. It is due to disease of the cilio-spinal centre. Occasionally it is caused by injury of the sympathetic nerve, and by pressure upon that nerve by aneurism or enlarged lymphatic glands. In tabes dorsalis the Argyll-Robertson pupil frequently follows upon the miosis as a later manifestation.

Paralysis of Accommodation (Cycloplegia).—This co dition results from involvement of one or more branch of the third nerve, causing the ciliary muscle to be paralyse The commonest cause is atropine. Both eyes may affected or only one. "Cases" (says Mr. Hartridge) " occur occasionally, though very rarely, of paralysis of tl ciliary muscle not involving the constrictor pupillæ Beside atropine, other causes are diphtheria, rheumatisr fever, masturbation, excessive venery, any complaint a lowering character (Hartridge), diabetes, syphilis, cerebr disease, reflex irritation, such as arises from a decayed tootl etc. Mandonnet gives also influenza and mumps. Tl affection usually comes on during the early convalescenc of the above-mentioned illnesses, but sometimes occurs a late as six weeks afterwards. There is blurred vision, ir ability to see near work—especially annoying to hypei metropes. Micropsia is occasionally complained of. Th prognosis varies with the cause. We try the patient at th distant types, and if he is able to read $\frac{6}{6}$ and yet unable t see the near type, it is obvious that there is paralysis o accommodation. Careful inquiries as to his antecedent will elicit the cause. The treatment is to prescribe suitabl convex glasses, the weakest that enable him to read fairl distinctly, only to be used for near work. If he is emmetropic a little less than +3 D to start with, gradually lessened, as the ciliary muscle gains in power. We must remember that in order to bring the emmetrope's far point from infinity to 33 centimetres (the reading distance) + 3 D is required ($\frac{100}{33}=3$). Pilocarpine or sulphate of eserine (gr. ss. to gr. i. ad ℥i.) may be ordered, and will temporarily relieve symptoms. Hartridge, speaking of eserine in these cases, says : "I think much good sometimes results from its use once every other day for some weeks, the ciliary muscle being made to contract, relaxing again as the effect of the myotic passes off." The local application of electricity is sometimes of benefit—2 to 5 milliampères, with the positive pole to the base of the occiput and the negative over the closed lids. Attention should be paid to the general health ; nux vomica, gelsemium,

iodide of potassium, arsenic, and other nerve tonics may be indicated. Dilute phosphoric acid is sometimes an excellent tonic for these cases, especially so in those cases that arise from masturbation and excessive venery. With or without medicine the post-diphtheritic cases invariably recover in a little time.

Spastic Strabismus.—Deviation of the eye, due to spasm of one or more ocular muscles, is a rare condition, comprising some cases of intermittent concomitant strabismus and choreic squint. Instances sometimes occur of conjugate deviation, the result of irritating cerebral lesions, hysteria, and epilepsy.

Nystagmus (Oscillation of the Eyeballs).—These movements are involuntary, exceedingly rapid, almost rhythmical, and affect both eyes at the same time. It has nothing to do with paralysis, nor yet has it anything essentially to do with functional strabismus ; but it is a rather interesting, odd affection, which generally finds a place in the text-books along with the other anomalies of the muscular apparatus. The oscillation is usually in the horizontal direction, but may be rotatory, vertical, or in the direction of a single muscle. It is as a rule permanent, but it may be periodic, and in some positions of the eye may have a point of rest. It is increased in near vision and from excitement ; in some cases it is complicated by similar movements of the head in an opposite direction. The vision is always impaired, but objects do not appear to move to, and are truly projected by, the patient. It is either congenital or acquired. In the former type there are optic nerve degeneration, opacities in the media, patches of choroiditis, and albinism. Although nothing to do essentially with squint, this may be a complication through the presence of corneal opacities, congenital cataract, amblyopia, etc. Congenital syphilis and disseminated sclerosis are frequent causes.

Slight cases can always be detected by finding oscillation of the optic papilla on ophthalmoscopic examination. Friedreich's ataxy is sometimes a cause of this disease.

The acquired form may be due to certain occupations. Miners who work underground in a constrained position

are specially liable to it when engaged in what is known as "undercutting." This requires the continuous upward turning of the eyes for long periods of time. The condition has been met with in various other occupations, and is to be looked upon as being due to fatigue of the muscles and exhaustion of their innervation (Baër, Snell).

Treatment.—Rest, abstinence from work, correction of existing refraction. Some cases seem to benefit by very small doses of agaricus muscarius, belladonna, and hyoscyamus tinctures. The congenital cases are beyond treatment.

PART III

DISTURBANCES OF MUSCLE BALANCE

CHAPTER XV

HETEROPHORIA AND HETEROTROPIA

PERFECT muscular equilibrium in every natural position is the normal state of the eyes. In a forced position they can only maintain their muscular balance by the exercise of effort. A condition I now propose discussing is that wherein this same exercise of effort has continuously to be maintained, not merely in forced positions, but in natural positions of the two eyes. The patient's eyes, in fact, are strained in a natural position, in the same way as they normally would be in an unnatural forced position. This condition of abnormal eye-strain is termed "heterophoria." Orthophoria is the term applied to the normal—that of perfect oculo-motor balance (Greek, ὀρθός, right or straightforward; φορέω, to balance or bear constantly). There is here the normal minimum of nervous effort in maintaining this condition, and when the eyes are at rest the visual axes are parallel.

In heterophoria (Greek, ἕτερος, the other, etc.), when the eyes are at rest—*i.e.*, not accommodating, but looking in the distance—the visual axes also are parallel, but only maintained so by means of a much larger degree of nervous effort, so that a divergence in one or other direction really is latent, and the individual only saves himself from experi-

encing diplopia by his desire for binocular vision—his tendency to squint, in fact, is kept under control because of the full development of his fusion faculty.

The normal condition—orthophoria—may be demonstrated by a simple experiment. A person with a normal pair of eyes fixes an object at about 30 centimetres' distance. As he looks steadily at it a sheet of paper is pushed in front of one eye, and that eye observed behind the screen thus placed before it. It continues to remain steadily fixed as before, because this is the position of equilibrium for the eye in relation to its fellow. The explanation given for this position of equilibrium is that it is the resultant of varying amounts of nerve force sent to the individual muscles and distributed among them in proper proportions.

Heterophoria differs from another condition that is termed "heterotropia" (Greek, ἕτερος, the other; τρόπος, a turn or direction). It is well to keep the meaning of these two words clearly in our minds, so as not to become bewildered by them. The student, when he encounters words of this kind should look up their meaning in a good medical dictionary, and make himself master of all technicalities. A patient of mine, when told that she had heterophoria, exclaimed, "I hope you do not mean anything like hydrophobia!"

Heterotropia may be regarded as a later stage of heterophoria. The effort to maintain the visual axes in their proper direction breaks down, and an actual deviation (squint) becomes manifest. Some surgeons, especially in America, apply the term to all cases of squint, while others speak of heterophoria as "latent squint." Both applications of these terms are, I think objectionable: they are misleading or pedantic. Why should a grandiose Greek name be given to such a common affection as ordinary squint? and it is misleading to think of young children having heterophoria, because actual squint has not yet become pronounced. I agree with Worth on this subject. He says: "A person whose fusion sense has developed perfectly, but who has a very high degree of heterophoria, will be able (with more or less suffering) to keep his devia-

tion tendency in check during the adaptable and vigorous periods of childhood and youth; but when he exchanges school life for some more trying and less healthy occupation, he may find himself unable to continue the struggle, in which event his heterophoria gives rise to an actual deviation. He then loses his asthenopic symptoms, but he suffers from diplopia, which is usually so annoying that he is glad to shade or close one eye. The degree of the manifest deviation increases during the first few weeks or months, after which it becomes stationary. The term *heterotropia* should be reserved for this rather rare condition, as it is obviously a further stage of heterophoria, and not a true squint nor a paralysis."

Heterotropia may be considered, therefore, to be a rare condition, in which the squint is due to loss of muscular balance of the two eyes in one or other direction. It differs from strabismus in occurring in older patients, never in children, and usually in young adults or adolescents. I have recently had a case where the age has been exceptionally young—that of thirteen years—for the onset of the actual squint. Before, however, giving the details of my own case, I think it will be more profitable for me to cite a typical case given by Worth. He relates it as follows: "I saw quite recently an exceedingly instructive case, a gentleman aged twenty. . . . From early childhood until one year ago the patient had suffered from severe headaches, coming on towards the end of the day. He had occasional diplopia, one image being over the other. He also had frequent attacks of typical migraine. During the last year he has seen double constantly, and the right eye has squinted downwards. He can still, by a great effort, overcome the deviation and blend the images. The diplopia is so intense that he is only comfortable when one or other eye is covered. But *since the hyperphoria gave place to an actual deviation, the headache and migraine have completely disappeared.* There is no important refractive error. Right eye deviates downwards (or left eye upwards) 8 degrees. Either eye deviates outwards 5 degrees. Prisms of this strength give binocular vision with orthophoria. I propose to advance

the left inferior rectus muscle, which I have no doubt will result in the cure of the whole trouble. If this operation had been performed many years ago, the patient would have been spared much unnecessary suffering."

The above case shows us several important facts, both as regards the heterophoria and its succeeding condition, heterotropia. One is that heterophoria is a congenital affection : " the patient had suffered from early childhood " —*i.e.*, from the beginning, when he first used his eyes. Another thing is that it bears no relation to refractive errors. His refractive error was slight, and yet he suffered from 8 degrees of latent vertical deviation relative to the two eyes—a left hyperphoria—besides 5 degrees laterally. Another fact was that he had perfect binocular vision and a well-developed fusion faculty, the former only becoming binocular diplopia when the latter was fatigued at times, and when subsequently it broke down altogether.

Because there was no amblyopia in the slightest degree in either eye, he had very troublesome diplopia, a striking thing about all his former symptoms being that they ceased upon the supervention of this new subjective symptom, and the heterophoria in a vertical sense giving place to this new objective sign—the downward squint. Another point was that heterophoria still continued laterally, for when tested he is found to have 5 degrees deviation of either eye outwards as well. Heterophoria is not so likely to break down laterally, owing to the strength of the internal and external recti muscles. Here we have another difference between heterotropia and ordinary squint, where the common thing is a lateral—*i.e.*, horizontal—deviation. The severe symptoms before the breakdown were especially due to the fact that the heterophoria was more especially vertical. Patients suffer much more from the vertical forms of this trouble than they do from the horizontal or lateral forms.

Heterophoria may be tested objectively by shading one eye with a screen, and observing whether the eye deviates behind it. Supposing, for instance, the eye deviates outwards : when the screen is withdrawn, there being an

outward squint of the eye covered, this eye has to recover itself by a movement inwards (movement of abduction). We observe, therefore, on withdrawing the screen this re-adjustment movement : the eye moves back in a direction precisely opposite to that of its deviation behind the screen. This latter movement of readjustment or redress is generally easier to make out than that of trying to observe the deviation, and much more the movement that caused the deviation on putting the screen before the eye ; hence it is currently employed as a means of recognizing the deviation. Thus, supposing we see a movement of redress inwards on taking away the screen, we know that there has been a deviation outwards behind the screen, and *vice versa*. In other words, we may say that a patient always has temporary heterotropia if one eye is screened, if he really has heterophoria with his two eyes uncovered. Take away from him temporarily his binocular vision by simply screening one eye, and the eye covered is bound to squint so long as it remains behind the screen. The condition of heterophoria is said to be due to some congenital malposition or malformation of the affected muscle. There is no paralysis, and unless it breaks down, no apparent squint—simply a greater amount of innervation needed for certain muscles to maintain perfect ocular equilibrium.

In his text-book of ophthalmology Fuchs has divided the causes of these latent disturbances of equilibrium into (1) organic and (2) functional. We should bear in mind, however, that the condition of unstable equilibrium in young children preceding the occurrence of ordinary—*i.e.*, functional—strabismus is a somewhat different thing from heterophoria. There youth and lack of development of the fusion faculty come in. True squint is intimately connected with errors of refraction ; heterophoria and heterotropia are independent of these anomalies. Fuchs has given myopia, and exhausting diseases enfeebling the eye muscles, among his organic causes, and as the chief functional cause interference with the normal relations that should exist between convergence and accommodation. Nothing is said by him about heterophoria being congenital, but other writers

have given this as a distinctive characteristic, also th fact that it has no relation to the refractive condition (the eyes. The tendency to faulty position naturally give rise to a great amount of discomfort, because, good visio existing in both eyes with the desire for binocular visior there is the constant effort needed to overcome a tendenc to diplopia. This continuous struggle is bad enough in horizontal direction, for the internal and external rec are comparatively powerful muscles, but the greatest amour of fatigue is when vertical differences exist. The effort t keep each image of one object simultaneously upon eac macula will soon tire the eyes. This is seen by the simpl experiment of trying to read with a rather weak prisı (about 2 degrees), apex up or down, before one eye. It car not be borne for long, whereas even a moderately stron prism (3 or 4 degrees) may be endured for some time place horizontally, apex in or out.

These cases of heterophoria are said to arise from th congenital imperfection or malposition of certain of th ocular muscles. Supposing, for instance, the right superic rectus muscle to be inverted slightly too near the upper edg of the cornea, or a little too nearly above its vertical meridiar or supposing one of the "upward movers" of the left eye imperfectly developed, then we can readily see how a cor dition of heterophoria, known as right hyperphoria, ma exist (see Chapter XVI.). It is easy, however, if we a not careful, to fall into an error in this connexion, sinc because a patient's right eye, on inspection, is seen to l manifestly on a higher or a lower level than his left, v must not jump to the conclusion that he has hyperphori If his visual axes are easily maintained parallel, it matte not where his two eyes are placed in relation to each othe there will not be any heterophoria of which hyperphor is a variety. It is incorrect to judge by the mere positic of the cornea : the estimate is made by the direction of tl line of vision, a totally different thing.

As may be readily surmised, the horizontal forms of tr heterophoria breaking down in young persons into a man fest divergence (heterotropia) are very uncommon. Pr

fessor Fuchs is undoubtedly right in the importance he gives to convergence and accommodation troubles as contributing etiological factors in these cases. "Asthenopia" (he says) "develops in cases of latent divergence, inasmuch as this prevents the continued maintenance of the proper degree of convergence required for all kinds of close work, like reading, writing, and all the more delicate varieties of handicraft. Hence the two eyes get tired when the work is carried on too long; the object looked at grows indistinct, and often appears double; and subsequently headache and even nausea set in. This condition is known as asthenopia muscularis (to distinguish it from accommodative and nervous asthenopia). A characteristic mark of it is that the asthenopic difficulties disappear at once if the patient closes one eye and uses but one for fixation, since then no convergence is required."

We may clearly see from the above how necessary it is to determine the amount of heterophoria that may exist in any given case after the refractive error be corrected, not only as regards the distant vision, but also vision in association with convergence and accommodation (*i.e.*, the near vision).

All varieties of heterotropia are, as a rule, concomitant. In this respect it closely simulates ordinary strabismus, and differs from the deviations of paralysis.

The details of my case of heterotropia, which was of the horizontal variety, are as follows:

"W. C. G., aged fourteen; schoolboy. Father died of consumption at the age of forty. Mother alive; healthy; aged thirty-five. No ocular trouble. When he came home for the holidays last Christmas, mother noticed for the first time a 'stand,' 'as if the eyeball turned in.' No squint had ever been noticed before then. She took him to an oculist, who ordered him glasses—+0·5 spherical—for reading. He never complained of any pain or headache. The squint seemed to have been only occasional at first, but lately it has been much more constant. On inspection of the eyes, nothing abnormal can be made out, except a distinct squint of the right eye, about 15 degrees. Vision of

right eye, $\frac{6}{9}$ H. M.* $0{\cdot}5 = \frac{6}{6}$; left eye, $\frac{6}{6}$ H. M. $0{\cdot}62 = \frac{6}{6}$. Tl mobility of the eyes is good in all directions. Well-marke esophoria (see Chapter XVI.) is discovered by the Maddc rod-test, requiring a 12° prism, apex in, to overcome. A the boy was going back to school the next day, it was n advisable to work out his refraction with a cycloplegi but he obviously had a slight degree of simple hyperm tropia, and he was ordered to continue what he was wearii for reading only. It was also advised that he should ha stereoscopic exercises while at school (see Chapter VII using Holmes' stereoscope and Kroll's pictures for half a hour every day, with bimanual drawing two or three tim a week.

"*January* 2, 1907.—Patient has been having the exerci as directed, and the eyes are very much better. The moth was in fear and trembling when she went to meet him the railway-station, and was agreeably surprised at t marked change in his appearance. There still remai about 3 to 5 degrees of internal squint, right eye, measur by the Maddox tangent scale. He can blend in the stere scope up to the card numbered I. 9 of the Emil Hegg seri Can manage all the Kroll cards except one.

"*January* 14.—The boy has been coming every morni the last ten days for an hour's exercise. He soon su ceeded with all the Emil Hegg cards, and then w Javal's cards. Can spell out all the French words of t latter (*lecture contrôlée*). I have therefore given him seve cards of my own design, making them as difficult as possib

"He can blend ordinary handwriting in duplicate or card, as well as the very fine print, small maps in duplica etc., reading it all without difficulty, even when th lines are drawn across many of the letters. The vision w both eyes is absolutely perfect, for he can read with e at 6 metres away the type for that distance. Th is now orthophoria for far and near. His squint l completely disappeared, and his mother is delighted w the cure."

* H. M. = manifest hypermetropia. See any work on Errors Refraction.

The diagnosis in this case rested upon four factors—namely :

1. The only slight and almost equal amount of refractive error ;
2. The age of onset of the squint ;
3. The absence of amblyopia (+0·5 spherical giving perfect vision in the squinting eye) ; and
4. Well-marked esophoria, at once discovered when his muscle balance was examined with the Maddox rod.

CHAPTER XVI

HETEROPHORIA (*continued*): ITS VARIETIES, EXAMINATION, AND TREATMENT.—CONCLUSION

It was Stevens, in America, who invented the generic term "heterophoria" for all latent deviation tendencies of th eye muscles. Looked at in the broader sense, we may speak of it as "latent squint," but this is not scientifically accurate for, as pointed out in the preceding chapter, it is importan that we should disassociate the term from those condition that produce the ordinary forms of squint where there is a defect of the fusion sense and generally considerable refractive error.

True heterophoria is essentially a motor anomaly. W are unable to say whether a muscle happens to be over strong (or a group of muscles), or whether there is undu weakness in one or more muscles. There is no overbalancin of innervation, for that would immediately result in a manifest and actual deviation. Nerve and energy, distribute to each muscle, is the very thing that is constantly calle upon, so as to preserve the balance of power. Nature, in the form of the human brain, abhors diplopia, and whethe a muscle happens to be acting at a greater mechanica advantage than it normally should act, or whatever th cause, the desire for binocular single vision causes a devia tion to be held back at the expense of exhausting nerv energy.

A large number of cases that occur in ophthalmic practice where there seems to be heterophoria, really are asthenopi cases due to considerable refractive error. These cases ar

properly termed "pseudo-heterophoria." The ametropia has never been corrected; all the symptoms are due to this cause, and although, when the refractive error is large in amount, this spurious heterophoria does not invariably disappear at once after commencing to wear the proper glasses, yet the asthenopic symptoms are quickly relieved, and it is only by means of one of the tests that the deviation becomes apparent. In my case-books I have numerous records of deviations under the Maddox rod, but most of them have been cases of refractive error relieved by suitable spectacles, and with whom the apparent heterophoria has subsequently disappeared. Strictly speaking, the term should only be used for those cases in which the anomaly persists after any refractive error has been corrected.

The varieties of heterophoria are as follows:

1. **Exophoria.**—The tendency is to an outward deviation—*i.e.*, a divergence of the visual axes.

2. **Esophoria.**—The tendency is to an inward deviation—*i.e.*, an abnormal static convergence of the visual axes.

3. **Hyperphoria.**—The tendency is for one or other eye to turn upwards or for the two eyes to turn vertically in opposite directions, so that one visual axis comes to lie in a higher plane than the other. According to the eye that tends to turn upward, it is spoken of as "right" and "left hyperphoria," and the eye is called the "hyperphoric eye."

4. **Cyclophoria.**—This is a condition that depends entirely upon insufficiency of one or other of the oblique muscles.

Other terms are sometimes used—namely (5) hyperexophoria and (6) hyperesophoria. These simply denote a tendency to divergence or convergence of an eye plus some amount of hyperphoria.

1. **Exophoria.**—This is a rather common variety of the affection, more especially if the cases associated with myopia and other refractive errors are included, these latter being classed as "pseudo-heterophoria" by some observers. The demands of modern education, by causing a constant overuse of convergence, bring about insufficiency of the internal recti, and render this variety on the increase. There is nearly always a defect of the dynamic convergence in

cases sufficiently pronounced to cause much inconvenience to the patient.

2. **Esophoria.**—Insufficiency of the external recti, and therefore tendency of the eyes to abnormal convergence. Authorities differ as to the frequency of this form. Stevens gives it as about two to one of the exophoric cases, and Noyes gives about 74 per cent. of all cases of muscular asthenopia. It undoubtedly plays a much more important rôle than exophoria as a predisposing cause to a variety of neuroses, and as the immediate cause of asthenopia it is also an element of considerable disturbance to the general health. I have recently had a case in point sent to me by a medical friend, which well illustrates the amount of nervous disturbance caused by even a moderate amount of esophoria. The patient was an extremely neurotic boy, aged fourteen years. He had been under medical treatment for a number of years, suffering from "all sorts of nervous ailments," and described by his doctor as being "a typical case of infantile hysteria," "a regular gamut of all sorts of aches and pains." He had, besides 2 degrees of esophoria, a slight amount of hypermetropic astigmatism. The binocular abduction was deficient, showing insufficiency of the external recti muscles. Attention to the eyes in this case greatly benefited his nervous condition and improved his general health.

Cases of esophoria, owing to their occasionally breaking down into temporary heterotropia, are no doubt frequently mistaken for "periodic strabismus."

There are some cases that are esophoric at the distance point and exophoric in accommodation. This occurs more frequently than one would suppose. It is best to base the diagnosis upon the condition that appears to be creating the most disturbance. If, for instance, the tendency to divergence worries the patient more, producing, after near work, headache and other asthenopic symptoms, such a case is best classed as one of exophoria. It is the exophoria in accommodative effort that is the cause of the symptoms. There is no doubt that the number of recorded cases of esophoria is much larger than it should have been, owing to

oculists in the past having only tested for heterophoria at the distance point, instead of testing for both far and near.

3. **Hyperphoria.**—A tendency for one eye to be tilted up, so that its visual axis rises above the normal parallelism that should exist, in a vertical sense, in relation to the visual axis of the fellow-eye. This is quite different, as already explained, from one eye as a whole being higher than its fellow. Clinically, this variety of heterophoria is the most important of all, because only a slight amount of the tendency to upward deviation is calculated to severely tax the patient and give rise to the most troublesome symptoms. It greatly depends upon the extent of prism duction that a patient may have in the opposite direction. The practice of investigating prism duction should never be neglected in testing any case of heterophoria.

Prism Duction.—The method is as follows: "The patient should be comfortably seated at 5 or 6 metres away from a candle-flame, gas-jet, or small electric light. He should be wearing a trial frame. While he looks steadily at the light the surgeon slips a 1° prism, apex up, in front of his right eye. Then other prisms, gradually getting stronger and stronger, are exchanged for the weaker, until the patient finds that he can no longer bear it without experiencing double vision. The highest prism that can be borne gives the extreme range of superduction of that eye. The same test is applied for the superduction of the left eye. Prisms, apex down for right and for left eye, give in the same way, subduction. With prisms apex out the power of binocular abduction is tested. Owing to its intimate association with accommodation, it is impossible to satisfactorily determine the exact amount of binocular adduction."

The normal limits of prism duction are given by Worth and other authorities as follows:

Superduction	.. ..	$1\frac{1}{2}$ to $2\frac{1}{2}$ degrees.
Subduction	.. ..	$1\frac{1}{2}$ to $2\frac{1}{2}$,,
Abduction	.. ..	4 to 5 ,,

Convergence may be greatly increased, and for that reason, if for no other, any measurement of it by prisms

is unreliable. No amount of practice can, on the other hand, increase duction power in the other three directions According to American authorities, associated conditions with excessive or insufficient power of convergence or divergence, may be stated as follows:

"In **Insufficiency of Convergence** or deficient dynamic convergence either orthophoria is present at 6 metres' distance, or there may be some degree of exophoria even at the distant point. There is marked exophoria at near distances. The near point of convergence may be even 8 or 10 centimetres away from the root of the nose. The adducting power is low and difficult to develop, and the abducting power is normal, slightly increased or decreased.

"In **Excessive Divergence** there is exophoria for near and far distances. The near point of convergence is normal, or nearly so. The adducting power is low, or may be normal and the abducting power is excessive.

"In **Insufficiency of Divergence** there is esophoria for distance and orthophoria, or possibly exophoria, for near vision. The convergence near point is normal. The adducting power is normal, and the abducting power is greatly diminished.

"In **Excessive Convergence** there is orthophoria, or slight esophoria, for distance, and marked esophoria for near vision. The near point of convergence is extremely close to the eyes. The adducting power is high, and the abducting power may be low."

Disturbances of vertical equilibrium affect the lateral equilibrium, and aggravate, or may even originate, lateral deviations.

4. **Cyclophoria.**—This condition is best determined at about 40 centimetres' distance by means of Savage's horizontal line test, to be presently described.

When there is a tendency for the vertical meridian of the eye to lean away from the median plane, the condition is termed "plus cyclophoria"; when, on the other hand, the leaning is in the opposite direction—*i.e.*, towards the median plane—the condition is termed "minus cyclophoria." These conditions may be easily understood if we remember

the action of the oblique muscles and the leaning of images in diplopia resulting from their paralysis, as discussed in Chapter XII. For instance, if the superior obliques act too feebly, the eyes tend to rotate round a sagittal axis so that their vertical diameters diverge above; in other words, there is plus cyclophoria. This is much more common than minus cyclophoria. Sometimes plus cyclophoria is associated with a condition that is rather rare, in which it happens that each eye alternately rolls upwards behind the Maddox rod (see "Maddox rod-test"). This condition is termed "double hyperphoria."

Symptomatology of Heterophoria.—The symptoms of these various disturbances of oculo-motor balance may even simulate grave organic nervous disease. The puzzled physician, unable to account for them, may attribute them to hysteria. There is nearly always constant headache; sometimes it is occipital, and sometimes it extends through the head from the eyes to the occiput. Frequently there is vertigo, with confusion of vision, especially when in the open air. It sometimes amounts to the condition that is known as agaraphobia. "The irritable eye" (says Osler), "the so-called nervous or neurasthenic asthenopia, is familiar to every family physician." Carriage exercise, travelling in tramcars, omnibuses, motor-cars and motor-omnibuses—all these tend to increase the nervous symptoms. There is pain between the shoulder-blades. The patient has a sort of consciousness that his eyes are not working in harmony. He feels as if he had lost control of them, "at times as if he squinted." If the strain is unrelieved, he has what he terms "bilious attacks," consisting of nausea, vomiting, and migrainous headaches. In children restlessness is a very marked symptom, but it also occurs in adults. There is no doubt that neurasthenia, epilepsy, migraine, and chorea, are all kept up in neurotic individuals by these muscular anomalies. Sometimes the conjunctiva appears congested, styes form, and there is blepharitis; but these local symptoms are the same as those of refractive errors. Occasionally there is some clonic blepharospasm. All the above symptoms are more marked in cases of hyper-

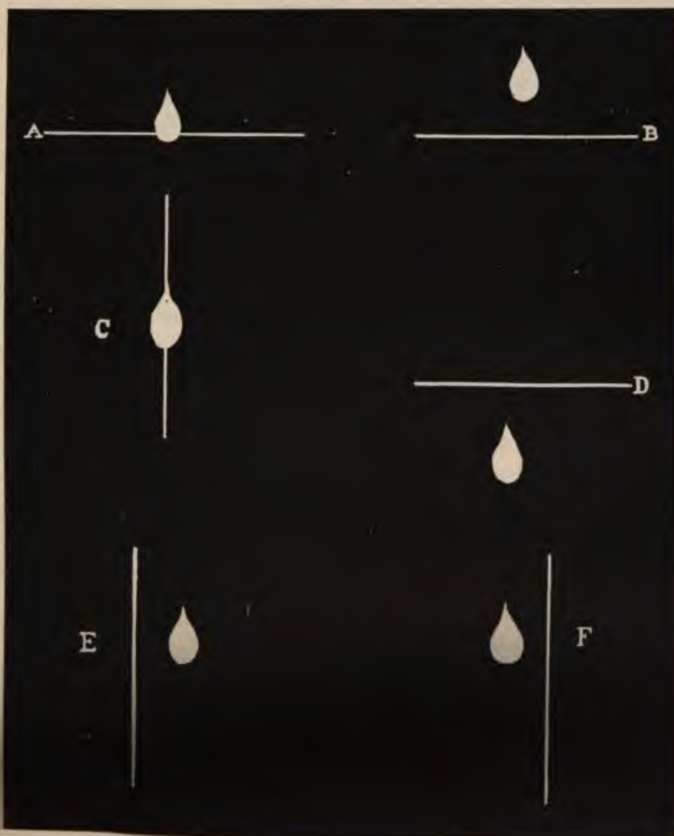
phoria and in cyclophoria, as a rule. The adduction (esophoria) and abduction (exophoria) varieties may exist without exciting severe symptoms, except where prism duction is much below the average. For instance, supposing in esophoria binocular abduction is deficient, given an extremely neurotic temperament, there will be all sorts of nervous troubles, as in the boy sent to me by my medical friend, whose doctor said that he had gone through "a regular gamut of all sorts and conditions of aches and pains." In exophoria the patient is more apt to suffer with ocular and head pains after using the eyes for near work. In esophoria the symptoms are more obscure and general and are not so likely to cause attention to be directed to the eyes as those in the other varieties.

Examination for Heterophoria.—In all cases the patient should be examined both for distant and near vision and the strength of the ocular muscles gauged accurately being compared with the normal standard by means o: prism duction.

There have been numerous instruments invented, of mor or less merit, for measuring heterophoria, or, at least, fo: determining its existence, some of which are only used b the inventors themselves. The Maddox rod-test is the on most generally useful for distance, and the Maddox doubl prism for near vision. An adjustable trial frame, test-cards and a set of prisms, whose axes are accurately marked, ar the other essentials for these tests.

The Maddox Rod-Test for Heterophoria.—This con sists of a small piece of thin glass rod set in a black disk Some disks have several rods placed closely side by side This has the advantage of giving a better streak of light. I order to more clearly differentiate the images, some disk have their rods coloured a ruby red. The disk is placed i the trial frame, that has been adjusted to the patient's eyes It is best to place it before the right eye. The patient shoul be seated at about 6 metres from the light, which is eithe a candle, gas-jet, or an electric lamp inside a box that ha a small hole, through which the light is seen. The roor should be darkened. With the axis of the rod vertical, th

image that belongs to the right eye is seen as a horizontal streak by the patient, and his left eye sees the bright candle-flame or other light, whatever it is. If the horizontal streak



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of light passes exactly through the flame, [illegible] in A, Fig. 49, there is no hyperphoria for distance ; if the streak is below the flame, there is hyperphoria of the eye behind the rods—*i.e.*, the right eye (B, Fig. 49) ; if the streak

is above, there is hyperphoria of the uncovered eye—*i.e.*, the left eye (D, Fig. 49). We now change the axis of the rods by rotating the disk, so that the rods lie exactly horizontal. If the streak passes vertically through the flame (C, Fig. 49), there is no esophoria nor exophoria—*i.e.*, the eyes are orthophoric laterally. If, however, the streak be on one or other side of the flame, there is heterophoria laterally. Supposing the patient sees the streak to the opposite side of the flame (E, Fig. 49), so that the uncovered left eye sees the flame on the right and the right eye sees the streak of light formed by the rods to the left of the flame, then we have crossed diplopia, and it is exophoria. In like manner, supposing the streak formed by the rods before the right eye is on the right, and the flame seen by the uncovered left eye is on the left (F, Fig. 49), then there is homonymous diplopia, and it is esophoria. The amount of esophoria or exophoria is measured by placing prisms before the uncovered eye, apex in or out, and of hyperphoria, apex either up or down. The prism which brings the streak exactly through the flame gives the measurement. For those who have sufficient wall space, the Maddox tangent scale is an excellent way of quickly arriving at the measurement without needing to use prisms.

To verify we may reverse, placing our disk containing the Maddox rods before the left eye, remembering that everything is now reversed; the exception to this being in cases of double hyperphoria, when both eyes roll up behind the rods.

In order to test the amount of heterophoria for near vision, the Maddox double prism is placed in the trial frame instead of the rods. It consists of two small prisms, each of 4 degrees, cemented base to base, inside the centre of a black disk. We must be careful to place these prisms so that their bases are horizontally situated in front of the right eye. A large square white card is given to the patient to look at, in the exact centre of which is a thick horizontal line 2 inches in length. The card should be large enough (about 2 feet square) to prevent its edges coming into the field of vision and so soliciting fusion. Owing to the two prisms in front

of the right eye, three lines are seen instead of the one line, the centre line belonging to the naked eye and the lines above it and below belonging to the eye covered by the two prisms. If the lines are equidistant and have their ends level (Fig. 52), there cannot possibly be any heterophoria

FIG. 50.—NO. 1 TEST-CARD.

in near vision. If the middle line appears parallel to the other two lines, there is no cyclophoria. Oculo-motor equilibrium is perfect in all respects. Supposing the middle line lies nearer the upper false image, there is right hyperphoria, because the two false images are relatively too low;

But I was got home to my little tent with all my

FIG. 51.—NO. 2 TEST-CARD.

and if the middle line is nearer the lower false image, there is left hyperphoria, because the two false images of the double prism are relatively too high. A little reflection will show at once that this must be so. The prism, base down, before the hyperphoric eye, which places the line

FIG. 52.—NORMAL APPEARANCE OF NO. 1 WHEN MADDOX DOUBLE PRISM IS BEFORE ONE EYE.

exactly half-way, gives the measurement of the degree of the anomaly.

In like manner, supposing the two left-hand ends of the false lines (images) are relatively to the true line (image) somewhat towards the left, so that the left-hand end of the true line lies somewhere between, there is exophoria—*i.e.*,

the visual axis of the right eye that sees the false images is too much to the left relatively to the visual axis of the left eye that sees the true image (crossed diplopia). The prism, base in, which brings all three ends in line, measures its degree; and in the same way, if the two right-hand ends of the false lines are too much towards the right, there is esophoria, and the prism, base out, will measure its degree.

If the patient declares that the middle line is slanting upwards or downwards on either side (as in Fig. 53), this will show that there is *cyclophoria*. A prism that corrects this measures the amount of cyclophoria, and might be worn. Carefully placed at the proper angle—theoretically,

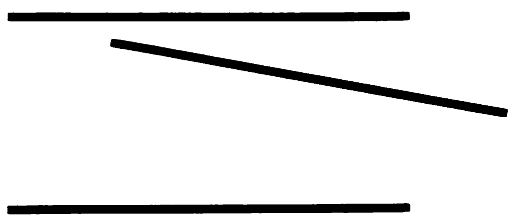

FIG. 53.—APPEARANCE WITH MADDOX DOUBLE PRISM IN A COMPLICATED CASE OF HETEROPHORIA.

The right eye has the double prism before it. The left eye therefore sees th true image, which is slanting down and to the right, showing, plus cyclo phoria, right hyperphoria, and exophoria.

at least—it ought to be a help. Suppose the middle lin (seen by left eye) appears to dip downwards to the left this shows that the vertical meridians of the eyes ar leaning in the opposite direction (minus cyclophoria) Should the middle line appear to be dipping downwards t the right (as in Fig. 53), there is plus cyclophoria.

As pointed out in the Appendix, the diploscope of Rém may be used for detecting and measuring heterophori (except cyclophoria). This has the advantage of measurin it at a medium distance, the types being 120 centimetre from the patient. A prism battery can be used, thus doin away with a trial frame, the prisms being square and rapidl changed. A useful instrument also is a rotatory prism This consists of two prisms of equal strength, so mounted

in a metal disk, that the apex of each coincides with the base of the other. In this position they, of course, neutralize each other. A mechanical arrangement enables the two prisms to be rotated in opposite directions, so that various prism strengths can be rapidly arrived at, the strength gradually increasing from zero up to the combined strength of the two component prisms. It is an excellent instrument for quickly determining prism duction. An index on the disk marks the various degrees of strength.

Some other tests may be briefly mentioned, described fully in the larger text-books. These are :

1. The equilibrium test of von Graefe. A strong prism, base up or down, is placed before one eye, which causes a double image to be seen—one immediately above the other if orthophoria, and displaced relatively to each other if exophoria or esophoria.

2. The parallax test of Duane. This depends on the movement of a light, seen at 6 metres (if heterophoria), on changing a card rapidly before one eye to the other.

3. The Cobalt glass test.

4. The cover test, already described, etc.

Numerous more or less expensive instruments have been devised, all of them excellent in their way, among which are Stevens's, Worth's, and the Harold Wilson phorometers.

Patients should always be tested for heterophoria, if at all ametropic, with their proper correction in glasses.

Treatment of Heterophoria.—This varies according to the character and form of the affection. In many cases internal medication is of distinct benefit if it be directed towards the underlying general condition. Faradism and galvanism are both recommended to restore muscle vigour. An extremely weak lotion of rue (*Ruta graveolens*) (recommended by Lauder Brunton) sometimes greatly relieves the painful strain of tired eyes (fluid extract, Parke, Davis and Co., gtt. iii. ; aqua rosæ, ℥vi.). Care must be taken that this lotion is weak, as patients are unable to bear it very strong.

A spirit lotion, applied several times a day to the closed lids, may also serve as a good local palliative.

Operation should be held in reserve as a last resource, and

treatment should be first of all directed towards increasing, as far as possible, the power of the weaker muscle. Exercises with Rémy's diploscope are of benefit, especially if prisms are used in these exercises. In any case prisms form an important factor in the treatment. Attempts should be made to increase the prism ductive power. Great increase may be expected as regards convergence, but not much in other directions.

Prisms may be prescribed as a palliative in esophoria and hyperphoria, when the opposite use—that of exercise—has failed. Care, however, must be taken that they are not so strong as to entirely overcome the tendency to deviation. It is not wise to relieve the weak muscle entirely of its burden, as it needs to be kept as much as possible in tone. Prisms used in this way, like a crutch, should always be divided in strength between the two eyes, and care should be taken that their axes are rightly placed. In hyperphoria, as regards exercises, I am convinced that the best practice is to prescribe two prisms, set in spectacle-frames—one with the base up for one eye, and the other with the base down for the other eye. They should be of sufficient strength to cause vertical diplopia with the two images close together. The patient should wear these daily for from ten to twenty minutes, making an effort to fuse the double images and keep them fused, looking through them at objects in a room and also at objects at greater distances, looking out of the window or in the garden. As the muscles gain more power, the strength of the prisms should be from time to time increased. In order that this treatment should not be overdone, it will be necessary to frequently test the degree of hyperphoria, so as to learn when to stop the exercises. An ability may be acquired to overcome, by these exercises, prisms of 12 degrees (the one of 6 degrees, base up, before the one eye, and the other of 6 degrees, base down, before the other eye), but it is more usual for patients only to be able to overcome a prism of from 5 to 8 degrees, and it sometimes happens that the hyperphoria is corrected when only a power to overcome a weaker prism of 5 degrees is acquired.

In the above method of treatment with prisms, providing patients will carry it out, we have more hope of success, and it is more scientific than the palliative treatment. The feeble muscle, instead of being given a crutch, as in the latter method, is exercised on the same principle as other voluntary muscles of the body are exercised—gymnastically. A patient with esophoria may be exercised in the same way. The prism is ordered with the base towards the nose. It may be a large square one, which the patient holds in his hand, being carefully instructed how to hold it so as to keep it quite horizontal, or with a less intelligent patient, two prisms, both having bases in, the combined strength of which equals the one, may be used. A power of overcoming the combined strength of 12 degrees to 16 can be acquired. In some cases of esophoria, even those breaking down into actual deviation, steroscopic exercises persevered in may effect a cure (see case of W. C. G., Chapter XV.).

In exophoria a different method has to be practised. Large square prisms, bases out, are held horizontally before one eye, the patient being seated 15 to 20 feet from a lighted candle. The surgeon commences by working up to a prism sufficiently strong to produce horizontal diplopia, the images being close together, so that they can be easily fused. The patient is then told to make an effort to bring the lights together, and hold the images together as one light. After this has been done, the prism is removed, and the same thing is repeated with a stronger one before the eye. Thus stronger and stronger prisms are put before the eye, until the patient is no longer able to fuse the images. It is, indeed, the exercise of the fusion faculty that is called into play. The same thing is repeated with the left eye, and thus both the internal recti muscles become strengthened. It is advisable to rest the eyes for a day or two between each of these sittings. A red glass may have to be employed before one eye, so that the images may be the more readily distinguished. If the degree of exophoria be very high, the patient may be given a set of prisms to exercise with at home, but always under the supervision of the surgeon. In lesser degrees the patient may come for his exercises to the

surgeon every other day, or every third day. Oculists who are too busy to carry this treatment out personally could arrange with other medical men who could give the time.

The prisms are always held so that the images are exactly on the same level, otherwise it is impossible for them to become fused. The power of the internal recti muscles can be increased, even up to 70 degrees. Supposing the prismatic lenses fail in a case, then, and not till then, should we have recourse to the prescription of prisms on the crutch principle. This latter, however, is preferable to operation, as the muscles after a time may acquire normal balance, and the prisms may be discarded. Even very weak prisms, after having been worn for a time, have produced good results.

Of course, in all cases the refraction should be carefully gone into, and corrected if found to be abnormal, and the exercises should always be carried out with the proper correction on.

With regard to operation, a great deal of enthusiasm has existed in America since Stevens introduced his graduated tenotomy, and also his advancement operation. It is far more brilliant, certainly, to give the sufferer relief by operative measures than by a more or less tedious course of treatment; but the question arises, Is it right to permanently lame or weaken the power of a muscle if our object may be attained in any other way? There is either insufficiency of one muscle or preponderance of strength in its antagonist. The best ideal of treatment is to strengthen the weaker muscle, and thereby establish the normal balance. Tenotomy does not do this. On the contrary, it weakens the stronger muscle so as to level it down to the weak condition of its opponent, and thus bring about equilibrium. If operation is really called for—and in some cases this happens after other measures have failed—Stevens's advancement operation, which places the weaker muscle at a greater mechanical advantage, seems to me the preferable procedure. It is performed as follows: "The eye is cocainized thoroughly, three or four instillations of a 4 per cent. solution of cocaine being made at intervals of three or four minutes. The lids are then separated with a speculum. A

fold of conjunctiva exactly over the centre of the insertion of the muscle is seized, and with the scissors a transverse incision is made through this membrane. This incision should not be too large. The tendon is seized with the fixation forceps at the exact centre of its attachment to the sclera, and a free tenotomy made. The forceps remains attached, or a silk loop is passed through to hold the tendon and to act as a guide to its exact centre. The tendon is then drawn out and the connective tissue between it and the conjunctiva loosened. When the tendon has been drawn out sufficiently to reach the point desired for its new attachment, it is seized at that point by the fixation forceps, and a V-shaped piece cut out with the apex towards the new attachment of the forceps. A fine but strong suture is now passed sufficiently behind the forceps to ensure a good hold, and then through the conjunctiva and some of the sclera near to the cornea and tied. The patient should be tested immediately after the operation, and the aim should be to secure a few degrees of excess over the actual amount required, as usually several degrees of effect are lost during the first forty-eight hours, owing to stretching or partial cutting out of the suture. It is always well to cover the eyes for a few days after an advancement to prevent traction upon the suture until some degree of new adhesion has taken place. For the operation of graduated tenotomy the preceding is the same as above with regard to the conjunctiva and first part of the operation. Care should be taken not to make a larger incision than ½ centimetre in length through this membrane. With the forceps pressing the outer cut edge of the conjunctiva backward, the tendon of the muscle is seized in its centre a little behind its insertion and divided with the scissors. The delicate Stevens's hook is then introduced through this opening in the centre of the tendon, and the opening enlarged by careful division of the tendon towards the borders until the desired effect is acquired. Under cocaine the patient experiences no pain, and the extent of the operation is regulated by frequent examinations with the phorometer. If too extensive, it may be limited by a very fine suture inserted through the

centre of the divided muscle and through the conjunctiva at the inner side of the wound, and tying it only sufficiently tight to have the desired effect."

In conclusion, I may say that I have endeavoured in these pages to show that, although operative measures are sometimes absolutely necessary in cases of ordinary squint, the later stages of ocular paralysis, and heterophoria, especially when this latter has broken down into heterotropia, yet much can be done, speaking generally, for all kinds of squint and tendency to squint by patience and perseverance in non-operative measures.

As regards children, it is preferable to wait, if they must be operated on for squint, until nine or ten years of age. Before this fear renders them restless and difficult to manage with only a local anæsthetic, and even at this age they suffer greatly from nervous apprehension when the neurotic element is at all marked. A general anæsthetic is inadmissible, because with it we cannot tell in the slightest what the after-effect is going to be. I once did a tenotomy under a general anæsthetic (chloroform) on a little girl of eight years. For a time I was immensely pleased with the result, but was disappointed subsequently when the child, who had lost her glasses, came back squinting as badly as ever.

To sum up, the important things to bear in mind in the common form of squint (convergent strabismus) are: The tendency to amblyopia, the lack of development of the fusion sense, and the intimate relationship that nearly all squint cases have with errors of refraction.

APPENDIX

USE OF THE DIPLOSCOPE

A.—FIRST TEST (FOR MEDICO-LEGAL WORK AS WELL AS SQUINT WORK).

(CONSONANTS ONLY.)

N.B.—All these Tests for Diagnosis are used as Exercises for Treatment.

THE left eye always sees the second and fourth letter. The right eye always sees the first and third letter.

The experiment is made in the first position of the

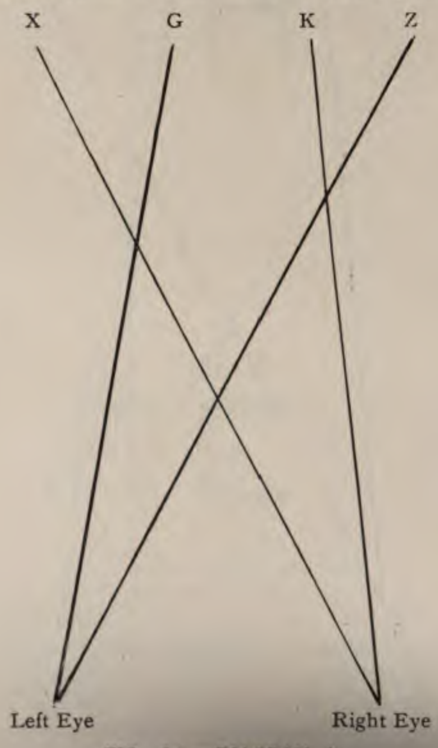

FIG. 54.—DIAGRAM A.

instrument. This consists in the opening of the holes the furthest apart from each other, and closing the other two.

(N.B.—The two open holes are placed horizontally, and consonants are used for the test type.)

B.—FIRST TEST.

(ALTERNATE CONSONANTS AND VOWELS.)

For Binocular Vision Only.

(N.B.—As there is the bare possibility of a shrewd malingerer guessing the order of these letters, if he has happened to see the card beforehand, this is not recommended for medico-legal work.)

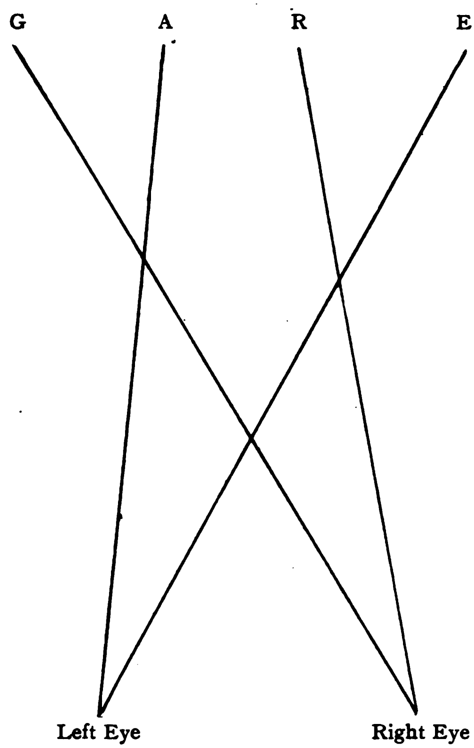

FIG. 55.—DIAGRAM B.

Three further tests founded upon the above pair are obtained by simply placing prisms before the eyes as follows:

1.	Two	prisms of	5	degrees,	bases	out,	before	each eye.
2.	,,	,,	5	,,	,,	in	,,	,,
3.	,,	,,	10	,,	,,	in	,,	,,

The same letters are seen by the same eye, but they are quite differently placed.

SECOND TEST.

The little bar (in front of the cylinder) is lowered vertically. The card used presents two letters, one vertically above the other. The two holes, opened in the first position, are moved obliquely, so that the upper one is in the position of eleven o'clock on a clock face, and the lower of five o'clock. This is easily done by the surgeon revolving the disc of the cylinder.

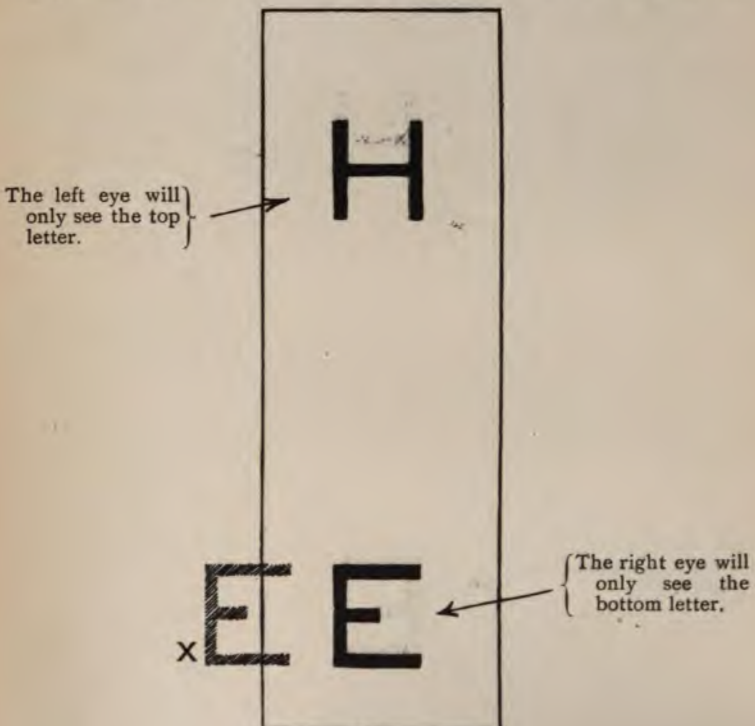

FIG. 56.—DIAGRAM C.

Should there be any esophoria, the two letters will not be vertically placed, as is the case when there is perfect m... balance horizontally. The letter H would be t... the left in relation to E, or, what amounts to t... E too much to the right in relation to H. ... diplopia is analogous to this.

If, on the other hand, as in Fig. 56, th... E will be at X—*i.e.*, too much to the lef... or H, the left-eye letter, too much to th... to E. Crossed diplopia is analogous

THIRD TEST.

The little bar is lowered vertically.

The holes are placed in the position of one and seven o'clock respectively.

Esophoria or exophoria may be confirmed with this test, remembering that the conditions would be reversed as

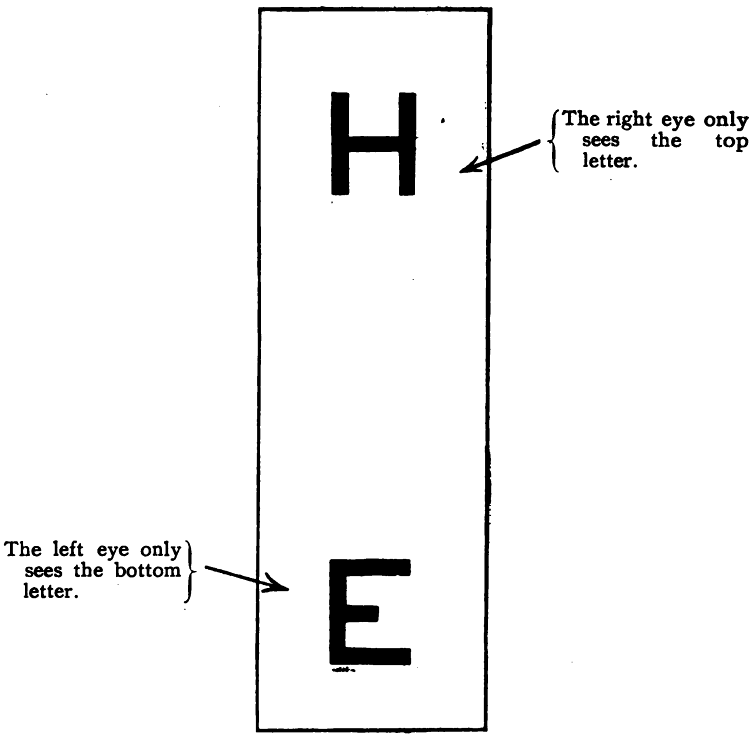

FIG. 57.—DIAGRAM D.

regards the letters—*i.e.*, for instance, in exophoria, H, being the right-eye letter, would be too much to the left in relation to E.

As in other tests for heterophoria, prisms can be applied to the eyes to overcome the loss of muscle balance. The prism which will bring the two letters exactly over each other vertically, as in the card, is the measure of the horizontal heterophoria.

FOURTH TEST.

The little bar is moved slightly towards the left. The holes are placed farthest apart and horizontally—*i.e.*, they are in the first position.

Part of the card is hidden by the bar, and to the right three letters should be seen.

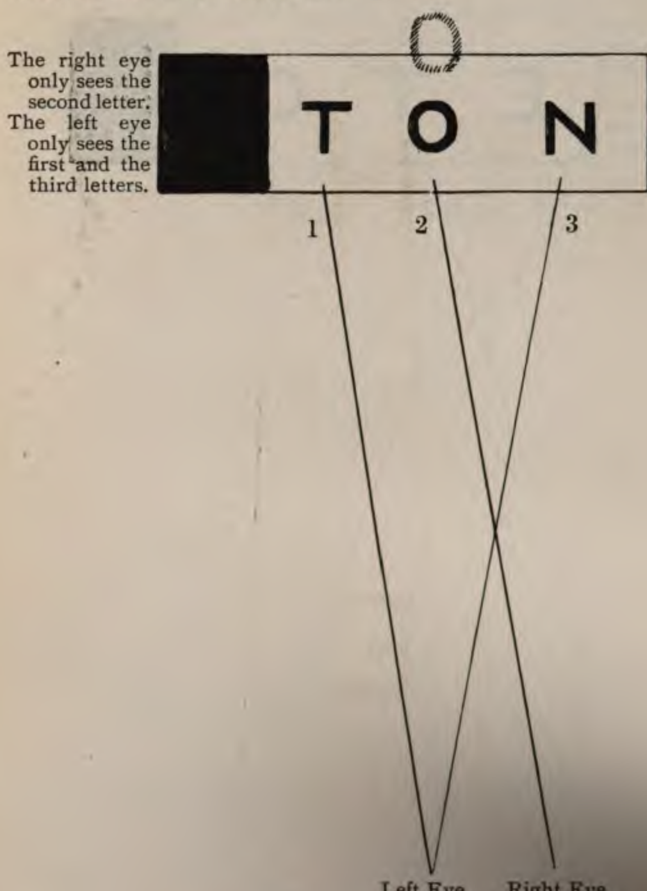

FIG. 58.—DIAGRAM E.

The above test will show left hyperphori
seen by the right eye is at a higher level tha
represented by the dotted O. The prism
down to its proper level is the measure of th

FIFTH TEST.

The little bar is moved slightly towards the right. No other change is made. Now the first three of the four letters on the cards are seen, and the fourth is hidden by the bar.

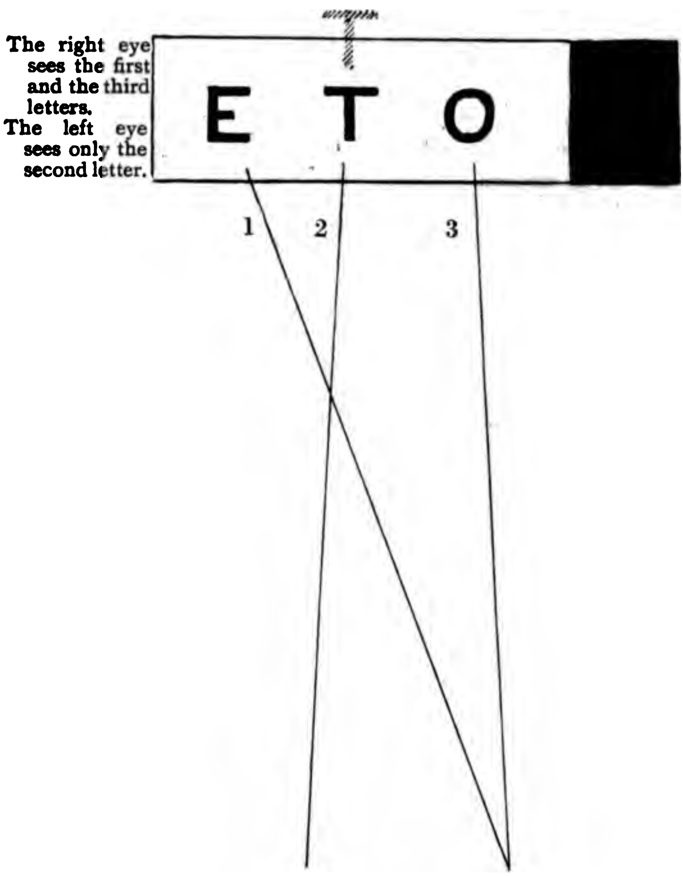

FIG. 59.—DIAGRAM F.

If right hyperphoria be present, the letter that is seen by the *left* eye will be on a higher level than the other two. Cyclophoria may be suspected if the letters appear to be tilted in relation to each other.

SIXTH TEST.

The little bar is raised completely. The two holes that are farthest away from each other are closed, and the two others are placed horizontally—*i.e.*, the second position. The two holes are now only about a centimetre apart.

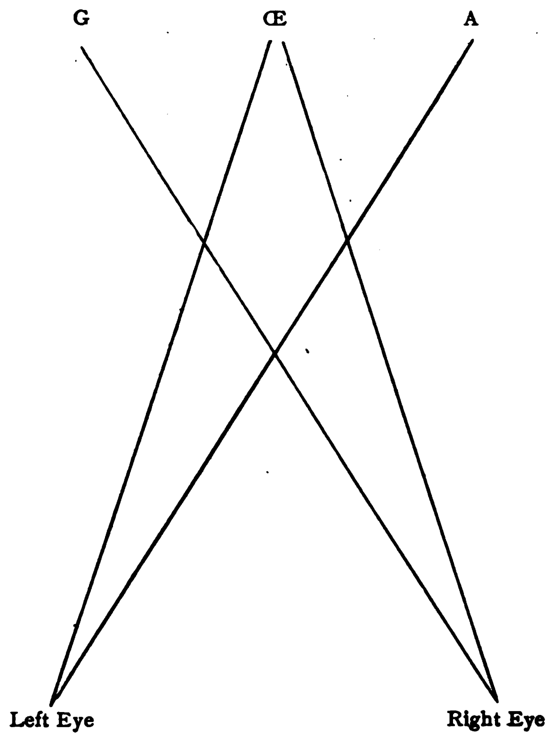

FIG. 60.—DIAGRAM G.

If binocular single vision and the fusion faculty be present, there will be blending of two centre letters, second and third of the card (in this case two vowels), so that they form a diphthong. This is like what obtains in stereoscopic vision.

The right eye should see the first letter and the diphthong. The left eye should see the last letter and the diphthong.

If the two centre letters are seen apart the fusion faculty is defective.

It is well to have vowels for the two centre letters, as diphthongs are more readily appreciated.

SEVENTH TEST.

This last test is quite unnecessary in my opinion, but it is given by Rémy as a corroborative measure for determining binocular vision. It is exactly the same as the previous one, except that the two outside letters are cut off by lowering the vertical bar, so that only the second and third letters are seen by the two eyes, forming a diphthong

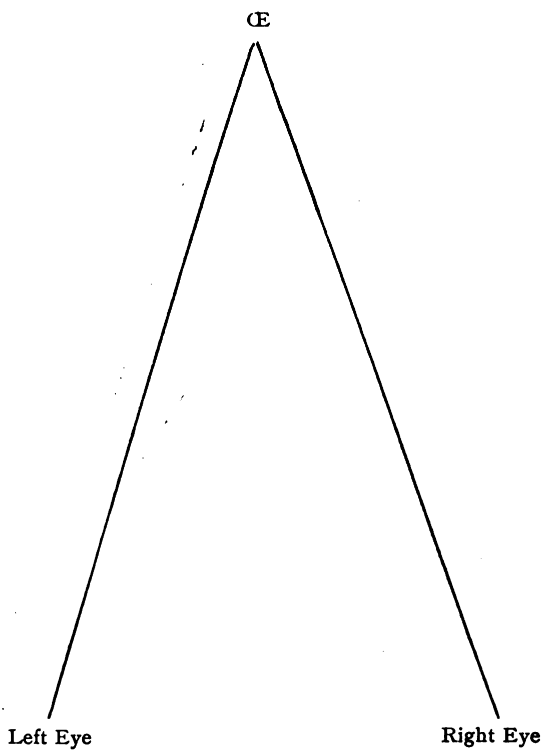

FIG. 61.—DIAGRAM H.

(Fig. 61). By previously shutting one of the holes we may easily determine whether a patient sees the diphthong with only one eye or with the two, for if the hole corresponding to his supposed seeing eye be closed, and he is amblyopic, he will see nothing, but if he has good vision with his two eyes he will still see one letter of the diphthong.

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